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THOUGHTS

ON

ANIMALCULES;

OR, A GLIMPSE OF THE

INVISIBLE WORLD

REVEALED BY THE MICROSCOPE.

THOUGHTS

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REVEALED BY THE MICROSCOPE.

BY

GIDEON ALGERNON MANTELL, ESQ., LL.D., F.R.S.,

AUTHOR OF THE "WONDERS OF GEOLOGY," ETC.

THE PHYSALIA PELAGICA, *page* 88.

"In the leaves of every forest—in the flowers of every garden—in the waters of every rivulet—there are worlds teeming with life, and numberless as are the glories of the firmament."

DR. CHALMERS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.

1846.

LONDON:
W. M'DOWALL, PRINTER, PEMBERTON ROW, GOUGH SQUARE.

TO

THE MOST NOBLE

THE MARQUESS OF NORTHAMPTON,

PRESIDENT OF THE ROYAL SOCIETY,

&c. &c. &c.,

THIS WORK IS MOST RESPECTFULLY INSCRIBED,

IN GRATEFUL ACKNOWLEDGMENT OF

His Lordship's

ZEALOUS EXERTIONS FOR THE ADVANCEMENT OF SCIENCE AND ART,

AND AS A

TESTIMONY OF THE HIGH RESPECT AND REGARD OF

THE AUTHOR.

Chester Square, Pimlico;
February, 1846.

7 X 9.1 9

"To the Natural Philosopher there is no natural object that is unimportant or trifling: from the least of Nature's works he may learn the greatest lessons."

SIR J. F. W. HERSCHEL.

"The likeliest method of discovering Truth is by the observations and experiments of many upon the same subject: and the most probable way of engaging people in such investigations, is by rendering such observations and experiments easy, attractive, and intelligible."

BAKER ON THE MICROSCOPE.

"I TELL thee that those living things,
To whom the fragile blade of grass,
That springeth in the morn
And perisheth ere noon,
Is an unbounded world—
I tell thee that those viewless beings,
Whose mansion is the smallest particle
Of the impassive atmosphere,
Enjoy and live like man;
And the minutest throb
That through their frame diffuses
The slightest, faintest motion,
Is fixed, and indispensable,
As the majestic laws
That rule yon rolling orbs."

SHELLEY.

PREFACE.

THE object of this Volume is to present a familiar exposition of the nature and habits of some of the invisible beings which people our lakes and streams; in the hope, that by placing the most interesting phenomena in a striking point of view, and describing them in language divested as much as possible of scientific terms, the subject may be rendered attractive to the general reader, and some intelligent and inquiring minds be led to the cultivation of a branch of natural knowledge, pre-eminently calculated to impart just and comprehensive views of the grandeur and harmony of the Creation, and of the Infinite Wisdom and Beneficence of its DIVINE AUTHOR; and which, in every condition

and circumstance of life, will prove a never-failing source of pleasure and instruction.

The Illustrations, with but few exceptions, are from sketches, taken with a camera lucida while the objects were under the microscope, either by my daughter or myself; they have been reduced to the size required for this work, by Mr. MOUNSEY, of Clapham Common, for whose kind assistance I feel much indebted.

The account of the structure and habits of the Animalcules, is based on the researches of M. EHRENBERG, and other eminent observers; but almost all the facts detailed, have come under, and are described from, my own observations on specimens obtained from the pools, and streams, around Clapham Common.

19, *Chester Square, Pimlico,*
London.

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THOUGHTS ON ANIMALCULES.

"THE majesty of GOD appears no less in small things than in great; and, as it exceedeth human sense in the immensity of the Universe, so also doth it in the smallness of the parts thereof."—HOBBES.

I.

INTRODUCTORY.—THE IDEAL INVISIBLE WORLD.

IN every country and in every age, a belief in the existence of beings invisible to mortal eye has more or less generally prevailed; and the air, the earth, and the waters have been peopled by ideal forms, invested with natures and attributes partaking of the characters of the minds from which they emanated. Hence sprang the Gnome of the mine and the cavern; the Goule of the charnel-house and the tomb; the beauti-

ful mythology of Fairy-land, and the dreamy creations of the ancient philosophers, who, like the Chaldeans,

> ——————————— watch'd the stars,
> Till they had peopled them with beings bright
> As their own beams.
>
> CHILDE HAROLD.

A sublimer creed succeeded, and is shadowed forth in the following noble lines of our divine poet:—

> ——— Nor think, though Man were none,
> That heav'n would want spectators, GOD want praise.
> Millions of spiritual beings walk the earth,
> Unseen, both when we wake and when we sleep!
>
> PARADISE LOST, BOOK IV.

This faith in the existence of supernatural beings, whose presence is but rarely made manifest to mortals, appears to be innate in the human mind. Its creations have varied with the progress of civilisation and refinement, and the inhabitants of the unseen world been invested with higher attributes and subtler natures; but the beautiful superstition, though modified, still retains its influence, and even yet throws its spell over the imaginings of the poet, and the speculations of the philosopher and the sage.

Who, in the bloom and freshness of youth, ere the

best feelings of the heart are blunted and perverted by the turmoil and cares of the world, has not felt an intense desire to remove the veil that shrouds from our senses the invisible creation, and hold converse with beings of a higher order than ourselves? Who has not experienced that yearning after the "Desert," and the "ministering Spirit," so finely expressed by Lord Byron, in a stanza of inimitable beauty and pathos?

> Oh! that the Desert were my dwelling-place,
> With one fair Spirit for my minister,
> That I might all forget the human race,
> And, hating no one, love but only her!
> Ye Elements!—in whose ennobling stir
> I feel myself exalted—Can ye not
> Accord me such a being? Do I err
> In deeming such inhabit many a spot?
> Though with them to converse can rarely be our lot.
>
> CHILDE HAROLD, CANTO IV.

And in after years, in those hours when, escaping from the vexations and excitements of active life, we fly for solace to the realms of fiction, and, giving ourselves up to the magic page of Shakespear, of Scott, or of Bulwer, forget for a while our anxieties and our sorrows, the visions of our early days will sometimes steal over us, we resign ourselves to the illusion, and once more the streams, the forests, and the air teem

with the spirits of the invisible world; the hallowed belief of our boyhood,

> Still lingering haunts the greenest spot
> In memory's waste.
>
> Moore.

In such a frame of mind we are unwilling to renounce our early faith, and are ready to exclaim, in the eloquent language of Sir Edward Bulwer—"Is there indeed no truth in our fictions of the unseen world? Are there not yet bright lingerers by the forest and the streams? Do the moon and the soft stars look out on no delicate and winged forms bathing in their light? Are the fairies and the invisible hosts but the children of our dreams, and not their inspiration? Are the chimeras of the passions the sole spirits of the universe? No! the trust in brighter shapes and fairer natures than the world knows of comes clinging to my heart!*"

But let us pass from the glowing fictions of the poets, to the calm reasoning and cautious inductions of the philosopher: "That there should be more species of intelligent creatures above us, than there are of sensible and material beings below us, is probable to me from

* "The Pilgrims of the Rhine," by Sir E. Bulwer Lytton, Bart.

hence, that in all the visible and corporeal world we perceive no interruptions, no chasms. Down to the lowest and most inorganic parts of matter, we find everywhere that the several species are linked together, and differ but in insensible degrees. And we have, therefore, reason to think that it is in accordance with the magnificent harmony of the universe, and the design and infinite goodness of its great Author, that the species of creatures should also by gentle degrees ascend upwards from us towards Infinite Perfection, as we see they gradually do from us downwards. We have, therefore, reason to conclude that there are far more species of creatures above us than there are beneath us; man being so much more remote from the Infinite Perfection of GOD, than from the very lowest state of being, or that which approaches nearest to nothing*."

That our planet may at the present moment be the abode of numberless invisible intelligences of a higher nature than man—as it was, in the ages antecedent to the creation of the human race, of thousands of beings now extinct—neither religion nor philosophy requires us to disbelieve†. However this be, all attempts to

* Locke's Essays.

† "The Scriptures assure us, that beings raised as far above the limited powers of man, as man is raised above the insect tribes, actually exist."—Dr. Dick's "Philosophy of a Future State," 2nd edition, p. 291.

commune with these spiritual existences, and render them manifest to our senses, have hitherto been in vain. Even the familiar of the Wizard, and the attendant spirit of the Magician (the reality of which, but little more than a century since, it was deemed heretical to deny), have passed into airy nothing, with the ignorance and superstition that gave them birth.

II.

THE INVISIBLE WORLD REVEALED BY THE MICROSCOPE.

But a fact not less startling than would be the realisation of the imaginings of Shakespear and of Milton, or of the speculations of Locke and of Bacon, admits of easy demonstration, namely, that the air, the earth, and the waters teem with numberless myriads of creatures, which are as unknown and as unapproachable to the great mass of mankind, as are the inhabitants of another planet. It may, indeed, be questioned, whether, if the telescope could bring within the reach of our observation the living things that dwell in the worlds around us, life would be there displayed in forms more diversified, in organisms more marvellous, under conditions more unlike those in which animal existence appears to our unassisted senses, than may be discovered "in the leaves of every forest, in the flowers of every garden, in the waters of every rivulet," by that noblest instrument of natural philosophy, the Microscope.

To an intelligent person, who has previously obtained a general idea of the nature of the objects about to be submitted to his inspection, a group of living animalcules, seen under a powerful microscope for the first time, presents a scene of extraordinary interest, and never fails to call forth an expression of amazement and admiration*. This statement admits of an easy illus-

* It is so absolutely necessary that the observer should previously have a general notion of the objects to be inspected, that I solicit the reader's attention to the following pertinent remarks of Captain Basil Hall.—"I have known many observant and quick-sighted men fail to perceive a double star in the heavens, while to others more practised, though using the same telescope, both objects were clearly defined. The secret often lies in knowing exactly what to look for, and thence learning how to adjust, not merely the focus of the eye, but what may be termed the focus of the judgment, so as to be able to pitch the understanding into such a key that the information may be understood when it comes. I remember being present once at the Geological Society, when a bottle was produced, which was said to contain certain zoophytes. It was handed round, in the first instance, among the initiated on the foremost benches, who commented freely with one another on the forms of the animals in the fluid; but, when it came to our hands, we could discover nothing in the bottle but the most limpid fluid,—without any trace, so far as our optics could make out, of animals dead or alive, the whole appearing absolutely transparent. The surprise of the ignorant at seeing nothing was only equal to that of the learned who saw so much to admire; nor was it till we were specifically instructed what we were to look for, and the shape, size, and general aspect of the zoophytes pointed out, that our understandings began to co-operate with our eyesight in peopling the fluid, which, up to that moment, had seemed perfectly uninhabited. The wonder then was, how we could possibly have omitted seeing objects now so palpable."

tration; for example — from some water containing aquatic plants, collected from a pond on Clapham Common, I select a small twig, to which are attached a few delicate flakes, apparently of slime or jelly; some minute fibres, standing erect here and there on the twig, are also dimly visible to the naked eye. This twig, with a drop or two of the water, we will put between two thin plates of glass, and place under the field of view of a microscope, having lenses that magnify the image of an object 200 times in linear dimensions*. Upon looking through the instrument, we find the fluid swarming with animals of various shapes and magnitudes. Some are darting through the water with great rapidity, while others are pursuing and devouring creatures more infinitesimal than themselves. Many are attached to the twig by long delicate threads, (the *Vorticellæ*, pl. III, fig. 3); several have their bodies inclosed in a transparent tube, from one end of which the animal partly protrudes and then recedes, (the *Floscularieæ*, pl. VII); while numbers are covered by an elegant shell or case, (the *Brachionus*, pl. XII, figs. 1, 2). The minutest kinds, (the *Monads*, pl. II, figs. 1, 6), many of which are so small that millions might be contained in a single

"Patchwork," by Captain Basil Hall, Vol. iii, p. 13.—London, E. Moxon, Dover Street, 1841.

* This is equal to 40,000 times in superficial dimension.

drop of water, appear like mere animated globules, free, single, and of various colours, sporting about in every direction. Numerous species resemble pearly or opaline cups or vases, fringed round the margin with delicate fibres that are in constant oscillation, (the *Vorticellæ*, pl. III). Some of these are attached by spiral tendrils; others are united by a slender stem to one common trunk, appearing like a bunch of hare-bells, (the *Carchesium*, pl. III, fig. 1); others are of a globular form, and grouped together in a definite pattern on a tabular or spherical membranous case for a certain period of their existence, and ultimately become detached and locomotive, (the *Gonium* and *Volvox*, pl. II, figs. 2, 9); while many are permanently clustered together, and die if separated from the parent mass. No organs of progressive motion, similar to those of beasts, birds, or fishes, are observable in these beings; yet they traverse the water with rapidity, without the aid of limbs or fins; and, though many species are destitute of eyes, yet all possess an accurate perception of the presence of other bodies, and pursue and capture their prey with unerring purpose.

The study of the nature and economy of these marvellous creatures must, however, be regarded not merely as an amusement for the gratification of an intelligent curiosity, but as a branch of natural knowledge fraught

with the highest interest; since, by a profound investigation of the modifications of structure and functions exhibited in these minute organisms, much light has already been shed upon some of the most obscure phenomena in the physiology of man. And there are still certain parts of the human frame, whose intimate structure and especial office are unknown, and will probably remain a mystery, unless revealed by observations on these minute forms of being; in which, from the transparency of their integuments, and the distinctness of their internal organs, the most important vital operations are submitted to our scrutiny.

In contemplating the swarms of living atoms under the microscope, the idea that most strongly impresses the mind, after the first sensation of surprise has subsided, is the infinitesimal minuteness, and simple condition of many of the structures, in which that marvellous principle, LIFE, is enshrined. We have been accustomed to associate the presence of vitality with bodies possessing various complicated organs for the elaboration and maintenance of the energies of existence; but here we see perfect and distinct creatures in the condition of single globules and cells, that live, and move, and have their being, and increase in numbers with a rapidity so prodigious, and in modes so peculiar, as to startle all our preconceived notions of animal organisation.

III.

THE HYDRA, OR FRESH-WATER POLYPE.

Plate I.

WITH the view of facilitating the comprehension of the vital phenomena that will come under our notice, when we enter in detail on the natural history of the animalcules selected as the subjects of these illustrations, I would first direct attention to the objects contained in this phial of water: they are living fresh-water polypes, or *Hydræ*, (pl. I.); animals that present considerable analogy in their structure to many of the simplest forms revealed by the microscope; and, being relatively of considerable size, and abundant in ponds and rivulets, they afford a convenient illustration of some of the most interesting physiological problems involved in the study of this division of animated nature.

The *Hydra** is common in almost every pool of fresh water, and is generally found attached to the stems or leaves of aquatic plants, or to twigs and branches that

* *Hydra*; so named from the fabled water-serpent, whose numerous heads were reproduced as often as cut off.

have fallen into the water. When in an expanded state it resembles a slender, semi-transparent cylinder or tube, about the size of a hog's bristle, from one-quarter to three-quarters of an inch in length, and which is constricted at the end that is attached to the plant. At the free extremity there is an aperture, or mouth, surrounded by several long, delicate, tubular arms, or tentacula, varying in number in the different species from six to ten. The polype, when contracted, appears like a little ball of jelly, scarcely one-tenth of an inch in diameter; and the arms are then shrunk into small papillæ, or eminences, forming a zone round the upper part of the body, (pl. 1, fig. 5).

There are four or five British species; the three commonly met with around London are figured in Plate 1.

I. The GREEN POLYPE, (*Hydra viridis*, pl. 1, figs. 1, 9).—This species is of a delicate green colour. Its body is cylindrical, but gradually becomes more slender towards the lower extremity. It has from six to ten tentacula, or arms, which are not so long as the body.

Fig. 1, represents three individuals attached to a twig, as seen expanded in a phial of water.

Fig. 9, shews a polype in four different positions, to illustrate its mode of progression. The polype performs locomotion by extending its arms and attaching

them to a fixed point, and then drawing its body to the same spot; the various attitudes it assumes in these movements are shewn in the figures: *a* denotes the base, or pedicle; and *b*, the head, or mouth.

The locomotive actions of the hydra are slow, but may readily be observed if that part of the glass to which the animal is attached be turned from the window; for the polypes, though destitute of any visual organs, always move towards the light, and quickly begin to shift from the dark side of the vessel, standing at first erect upon the pedicle, and throwing their arms forwards and fixing them, thus bending the body archwise, and at length drawing the tail towards the head, as shewn in pl. I, fig. 9.

II. The COMMON POLYPE, (*Hydra vulgaris*, pl. I, figs. 2, 4, 8).—The body is of a cylindrical form, and of an orange-brown colour. It has from seven to twelve arms, which are a little longer than the body.

Fig. 2, a polype contracted.

Fig. 5, a front view of an individual still more collapsed.

Fig. 4, a polype, with two young ones, of different ages, shooting out from the body.

III. The LONG-ARMED POLYPE, (*Hydra fusca*, pl. I,

figs. 3, 6, 7).—The body is of a brownish colour, and its lower half much more slender than the upper part. The arms are, in general, from six to eight in number, and several times longer than the body.

Fig. 3, an individual with the arms fully extended in quest of prey. A red worm (*c*), and a small water insect (*d*), are seen captured by the tentacula.

Fig. 6, a polype bending its body, and throwing about its arms in an undulating manner in search of food.

Fig. 7, a red worm partly drawn into the stomach of a polype, being too large to be swallowed entire.

Fig. 8, a vertical or longitudinal section of a polype, *highly magnified*, to shew the internal structure: *e*, the cellular tissue, which forms the constituent substance of the entire animal; *f*, the tubular arms; *g*, the inner surface of the digestive sac.

The Hydra, when taken out of the water, shrinks into a small round mass, which, examined under the microscope, is seen to be composed of cells, and of greenish or reddish brown granules, loosely connected by a glairy mucus. The cells are condensed on the external surface, so as to constitute a double layer of integument; but the lining of the cavity of the body is made up of cells that are transversely elongated, and forms a surface which is covered with exceedingly minute eminences, termed *villi*, from the resemblance to the pile of velvet.

If a piece of stem or leaf to which some polypes are attached, is put into a small clear phial filled with water, and placed on the cell of a window where the objects can be conveniently examined, the little animals will in a short time extend and spread out their arms in quest of prey; and, if a small lively worm is dropped into the water, they quickly rouse into full activity, while the worm, apparently conscious of its danger, throws itself into violent contortions. One of the polypes then stretches out its arms, perhaps to the length of several inches, till they become as attenuated as a spider's web, and suddenly seizes and entangles its prey, (*see* pl. 1, fig. 3, *c*), which in a moment, as if paralysed by an electric shock, ceases its struggles, and is then slowly drawn to the mouth, and swallowed, (*see* pl. 1, fig. 7). The body of the hydra now becomes distended; digestion rapidly takes place, as is shewn by the diffusion of the red colour of the worm through the substance of the polype; and, after some hours, the indigestible portions are rejected by the mouth.

In watching this experiment, the extraordinary powers possessed by the tentacula—those apparently mere attenuated threads—cannot fail to arrest attention. These instruments, when stretched to the utmost, (*see* pl. 1, fig. 3), are as fine as the finest cobweb; but a high magnifying power shews them to be tubular, and filled

with fluid, their substance being a congeries of cells and granules like the rest of the body, of which, indeed, they are only prolongations. The arms have rows of minute eminences or nodules spirally arranged, which can be exserted and drawn in at pleasure. This structure may account for the security with which the living prey is retained in spite of its struggles, but will in nowise enable us to explain how instruments so delicate can resist the violent contortions of worms and other relatively powerful animals. I have seen a polype seize two large worms at the same instant; and, to reach them, the arms were extended to such a degree of tenuity, as scarcely to be perceptible without the aid of a lens; and the worms, though very lively, and struggling violently, were unable to break asunder these delicate instruments and escape, but in an instant were struck motionless. This phenomenon strikingly resembles the effect produced by the *Gymnotus*, or electrical eel; and it is not improbable, that the Hydra, like that fish, kills its prey by an electric shock.

IV.

THE DIVISIBILITY OF VITALITY.

THE most extraordinary vital endowment possessed by the Fresh-water Polype, is that of the reproduction of lost parts to an almost unlimited extent, even to the *formation of several perfect individuals from the divided parts of a single Hydra.* If a polype is cut across transversely, the upper part with the arms quickly produces a new body and tail; and the lower portion as rapidly throws out another body and arms. If the body is slit down longitudinally, and left united at the base, each portion grows into an entire polype, the requisite number of arms shoot out, and two perfect animals attached to one common base are produced; and, if the division be complete, two free hydræ are the result. *One polype was cut into ten pieces,* and *each piece grew into an entire animal.* If a polype is turned inside out, a transmutation not less wonderful, physiologically considered, than the above process takes place: the original outer surface performs the function of digestion, while the former lining of the stomach becomes the external integument

or skin; the animal apparently suffering no inconvenience from the operation.

The discovery of this marvellous power of reproduction in the Hydra, was made about a century since by a M. TREMBLEY, then residing at the Hague, who, in the course of some researches for small aquatic insects, was struck with the apparently spontaneous movements of some delicate fibres which he supposed were the roots or tendrils of plants growing in the water. Finding that these fibres contracted when touched, and extended themselves again if left undisturbed, he at first surmised that their motions were analogous to those of the sensitive plant; for the bodies in question were so unlike anything at that period recognised as belonging to the animal kingdom, that their true character was not suspected. Repeated observations, however, convinced M. Trembley that these movements were much more active than any apparent in vegetables, and he was greatly perplexed as to their real nature; he, therefore, resolved to submit the supposed plants to an experiment, which he naturally thought must be conclusive. Accordingly he selected several specimens detached from the stem of a plant, and cut them to pieces, leaving them, after the subdivision, in a glass with water, and then patiently and cautiously watched the result. To his utter astonishment, each portion preserved its vitality, and grew up into a perfect

whole. Their vegetable nature was, therefore, at first, deemed unquestionable; but M. Trembley having noticed the spontaneous motions of the mutilated polypes as they advanced to perfection, with great sagacity inferred that they were true animals, possessing a structure which, like that of certain plants, admitted of subdivision, without destroying its vitality or powers of reparation.

It may easily be conceived how great was the astonishment excited by this discovery; and its announcement was received with hesitation by some, and ridiculed by others. Such, however, was the curiosity awakened among the naturalists of this country, that the then President of the Royal Society, Martin Folkes, repeated the experiment upon some polypes sent to him by M. Trembley from Holland; for, although the ponds and rivulets around London abounded in these animals, and their existence had been made known forty years previously by the celebrated Leeuwenhoek, the fact appears to have been entirely overlooked or forgotten. Subsequently, Mr. Henry Baker, an eminent microscopical observer, verified the statements of M. Trembley in every essential particular, and published the result of his experiments in an interesting volume, which is still the best English work on the subject*.

* "An Attempt towards the Natural History of the Polype. By Henry Baker, F.R.S., London, 1743." One volume, 8vo, with numerous ligno-

graphs. Such of my readers as indulge in the luxury of a hunt over the old book-stalls may be so fortunate as to meet with a copy of this work. But those who feel particularly interested in the subject, should endeavour to procure M. Trembley's 4to, intitled "*Mémoires pour servir à l'Histoire d'un Genre de Polypes d'Eau douce. Par A. Trembley, de la Société Royale. A Leide*, 1744." This volume is one of the most delightful contributions to natural knowledge ever published: its narrative is enlivened by so refreshing an enthusiasm, its descriptions are so graphic, and the illustrations so faithful, and in the highest excellence of art, (being engraved by the celebrated Lyonet), that it is worthy of a place in the best libraries. I obtained a copy some years since through M. Baillière, the foreign bookseller, Regent Street, London.

V.

CELLS, THE ESSENTIAL ORGANS OF LIFE.

The interpretation of these phenomena is to be found in the peculiar organisation of the Hydra: its entire structure being nothing more than an aggregation of cells. A vertical section of a polype (*see* pl. 1, fig. 8), shews the internal cavity or digestive sac, the relative thickness of the substance of the body, and the manner in which the arms are formed by a prolongation of the upper part into hollow processes. The entire animal consists, in fact, of a simple cavity formed of a congeries of cells, for the reception and assimilation of food. The cells lining the stomach select and absorb the nutritious particles, and the tube then spontaneously contracts, and casts out the residue of digestion. The organisation of the polype is, therefore, analogous to that of the simplest condition of the vegetable kingdom, the *Cellulosæ;* for, even in the large Fuci, or sea-weeds, the whole fabric consists of cells. The fresh-water *Confervæ* are merely jointed films composed of cells, which contain granules or lesser cells. A cell bursts, the granules escape, float

in the water till they become fixed to some other body, and then reproduce cells, which are aggregated after the same pattern as in the parent plant. The common mould or mustiness is a cluster of plants formed of cells only: and there are some vegetables in which the entire plant consists of but *one isolated cell;* such are the yeast fungus (*Torula cerevisiæ*), and the red snow (*Leparia nivalis*). In these examples we have proof that all those functions in which the organic life of vegetables essentially consists, namely, absorption, assimilation, the fixation of carbon from the atmosphere, respiration, exhalation, secretion, and reproduction, are effected by one simple cell. Even in the highest and most complicated orders of vegetables, in which there is a variety of organs adapted for the performance of different offices, these functions are performed by the agency of cells, which obtain materials of formation and support from the ordinary chemical agents around them. Thus, an aggregation of simple cells forms the cellular tissue; a fusion or blending of several cells produces the vessels, and so forth; and by cells are elaborated the gum, resin, oil, starch, gluten, &c.; and, by cells specially endowed, are secreted the narcotic of the poppy, the deadly poison of the nightshade, and the stimulant aromatic of the clove. In like manner, in animal structures, all the various processes of vitality are performed by cells or globules,

varying in size from infinite minuteness to forms visible to the unassisted eye. In fine, a minute globular cell is typical of the common germ from which all organic fabrics proceed. All animals and plants may justly be regarded as definite aggregations of cells, endowed with specific properties in the different types, and subjected to a never varying law of development*. And in animals, as well as in plants, there are certain kinds in which the

* Although it is now a received physiological axiom, that cells are the elementary basis, the ultimate limit, of all animal and vegetable structures, and that the varied functions in which organic life essentially consists are performed by the agency of cells, which are not distinguishable from each other by any well marked characters, there is not the slightest ground for assuming any *identity* between the primary cells even of the simplest species of animals or vegetables, much less between those of more complicated organisation. The single cell, which embodies vitality in the yeast fungus or in the monad, is governed by the same immutable organic laws which preside over the complicated machinery of Man and the other vertebrata; and the single cell, which is the *embryotic condition* of the Mammal, has no more relation to the single cell, which is the permanent condition of the Monad, than has the perfect animal into which the mammalian cell ultimately becomes developed. The cell that forms the germ of each species of organism is endowed with special properties, which can result in nothing but the fabrication of that particular species. The serious error which pervades the theory advanced in the work intitled "The Vestiges of the Natural History of the Creation" has arisen from its author having, in many instances, assumed *analogy* to be a proof of identity. There is an *analogy* between the human embryo and the monad of the Volvox, in that each consists of simple cells; but there is no more *identity* between the human and the polygastrian cells, than between the perfect man and the mature animalcule.

entire animal consists of but one single cell, (*the Monads*); and others, in which each individual is but a cluster of such cells arranged in a definite manner. These mere aggregations of simple cells perform all the functions of animal life, namely, the maintenance of a particular form for a certain duration of time, the elaboration of materials of support from food, locomotion, and the continuation of the species; hence, these animals, like the simplest plants, may be divided without destroying their vitality, and every part may become a perfect individual*. To this class belongs the Hydra,

* Since, therefore, the extreme point to which we can trace animal organisation is a cell, and all the important processes by which the fabric is renovated and maintained are performed by the agency of cells endowed with specific properties,—some secreting the bile, others the fat, others the mucus, and so forth,—it follows, that, upon the integrity of the structure and function of a cell, or of a cluster of cells, may depend the maintenance of health; in other words, that the first germ of disease may arise, and for awhile lie hidden, in these integral elements of animal organisation. Hence, we can understand how mental emotions, by disturbing or weakening the vital influence transmitted by the nerves to the cells of any particular organ, may impair the structure and vitiate the secretions, and ultimately induce extensive local disease, long after the cause of the physical derangement has passed away, and is forgotten. Of the truth of this remark, pulmonary consumption, alas! affords every day the most unequivocal and melancholy proofs. But the Tree of Knowledge yields good as well as evil fruit; and, if recent microscopical discoveries are calculated to alarm the timid, by shewing what slight causes may lay the foundation of fatal diseases, on the other hand, they encourage the cheering hope, that, by patience and perseverance, we may at length learn how to detect the

and the above exposition of its structure renders the phenomena previously described, namely, the production of several perfect animals from the vivisection of an individual, perfectly intelligible.

The formation of the young polypes by gemmation or buds, as in certain plants, is in accordance with this simplicity of structure. A small protuberance appears externally on some part of the body of the polype, and gradually enlarges and becomes elongated; arms speedily shoot forth from the free extremity, and a miniature Hydra

first stage of disordered action, and correct the functional derangement, ere the structure of the organ is seriously impaired. And, since the first germ of disease is located in the cells, reason suggests, and experience confirms the propriety of employing our remedial measures in such manner as shall ensure, as far as possible, their direct influence on the intimate structure of the affected organ. Thus, in certain morbid conditions of the lungs and air-passages, the inhalation of vapour impregnated with those substances that are known to act beneficially in such affections is the most effectual mode of treatment, and that which, above all others, according to my experience, holds out the fairest prospect of cure in the early stage of Consumption, and the most certain alleviation of the distressing symptoms which but too frequently attend its progress to the fatal termination. Even with our present limited and imperfect experience of the effects of the inhalation of certain remedies in *phthysis*, such beneficial results have been obtained, that, in the acknowledged inutility of all other measures, (not excepting change of climate, which it is the fashion to estimate very far above its real value), the neglect of this *probable* means of cure, and of *certain alleviation*, cannot be too strongly condemned. The importance of the subject will, it is hoped, excuse this digression.

is formed; (*see* pl. I, fig. 4). In a short time the young separates from the parent, and assumes its individual existence. Frequently several young ones, in various stages of growth, appear on the same polype, and even a third or fourth generation on the young themselves, before their separation from the parent. Upon an average, each individual sends out five or six young in the course of a week; the progeny of a single polype, may, therefore, in a few months, amount to hundreds of thousands.

VI.

THE INFUSORIA, OR FRESH-WATER ANIMALCULES.

From this sketch of the natural history of the Hydræ, we pass to the examination of the group of living animalcules sporting in the drops of water between the two small plates of glass placed in the field of the microscope; and, as it comprises species of several families, it will afford us a satisfactory elucidation of many interesting particulars relating to the structure and economy of this class of animals. To examine these objects in detail, we must successively select a particular species, remove it from the group, place it in a drop of pure water, and inspect it under the microscope with different powers; beginning with a low magnifier, that we may first obtain a general knowledge of the form and appearance of the species, whether single or in clusters; and afterwards examine the several parts of the body with the most powerful glasses*. It was by patient and persevering

* The scope of this volume does not admit of practical directions. Mr. Andrew Pritchard's "Microscopic Illustrations" will be found to contain the required information.

investigations of this nature, and by experiments conducted with great sagacity and caution, that the eminent naturalist M. Ehrenberg, discovered the interesting facts relating to animalcular life, which have so astonished and delighted the scientific world*.

Our examination will begin with those animalcules which are of the simplest structure—the *Monads;* but some preliminary remarks are necessary to elucidate a few general phenomena, which are observable either in certain groups, or in the whole class.

The existence of these minute beings having been first detected in water containing vegetable matter, such as hay, grass, &c., it was taken for granted that they were peculiar to certain infusions; hence the term

* M. Ehrenberg's splendid work is intitled "Die Infusionsthierchen als Vollkommene Organismen. Ein Blick in das tiefere organische leben der Natur. Leipzig, 1838." It is in one volume, folio, with sixty-four plates, containing many hundred figures coloured from nature. It is indeed a most extraordinary production, whether we consider the prodigious labour, profound knowledge, and eminent talents for observation required for the successful investigation of the subject, the surpassing excellence of the drawings, or the marvellous nature of the beings which are therein delineated and described. The reader who has not seen this work, though he may have surveyed the beautiful and curious forms which these unpretending pages are designed to illustrate, can have no adequate idea of the fantastic shapes, and the almost endless diversity of form and structure, which animal existence assumes, even in our own planet, in the regions from which the microscope withdraws the veil.

Infusoria given to this class of animals, in allusion to their supposed origin. This name is still employed as a general designation, although it has long been known that the presence of animalcules in infusions has no necessary relation to the vegetable ingredients, except so far as the decomposition of the latter may tend to the production of a proper medium, for the development of the invisible eggs, or germs, of these creatures, which are everywhere present. The essential characters of the Infusoria—in other words, those points of their organisation in which they differ from all other animals—consist in their bodies being destitute of any true articulated or jointed limbs and locomotive members or feet; their varied movements being performed by means of peculiar processes, or filaments, which are always in motion, and are termed *Cilia**, from their supposed resemblance to the eyelashes. The cilia, in many species of Infusoria, are more or less generally distributed over the surface of the body; in others, they are disposed in one or more circles around the mouth or aperture of the digestive organs; and, in some, are arranged in zones on one or more circular, or semicircular projections, on the upper part of the body. In the last modification, the successive action of the rows of cilia

* *Cilia*, the plural of *cilium*, an eyelash.

produces an appearance of a rotatory motion, like that of a wheel on its axis; and this resemblance is so striking, that the name *Rotifera*, or wheel-bearing animalcules, is given to the Infusoria possessing this character; which are also further distinguished, by a more highly endowed organisation than the other species. The Infusoria are therefore arranged by Ehrenberg in two classes, which are respectively designated POLYGASTRIA, and ROTIFERA.

VII.

THE POLYGASTRIA, OR ANIMALCULES WITH MANY STOMACHS.

THE POLYGASTRIA, (*many stomachs*), as the name imports, are characterised by having a digestive organ, which, instead of being a single pouch or cavity, as in the Hydra, is composed of numerous little globular bladders, (*sacs*, or *sacculi*), connected together by one common tube; and these clear globular cells or stomachs, receive and assimilate the nutriment when in a sufficiently molecular or divided state. From the transparency of the bodies of the animalcules, the cells, when filled with coloured food, are easily distinguished, as we shall presently prove by an interesting experiment.

The Polygastria present great diversity of figure; their movements are performed by the cilia, which are distributed over the body; they increase either by spontaneous division, or by gemmules or buds. This class comprises the minutest forms of animal life hitherto reached by the most powerful microscope. Some kinds (*Monas vibrio*) do not exceed one three-thousandth of a

line (one-twelfth of an inch) in dimensions. The largest species; as, for example, the *Stentors*, are visible to the naked eye; and these are not more than two-thirds of a line in length. But these living atoms are often clustered together in such inconceivable numbers, as to form considerable masses, of various colours. The Polygastria occur both in fresh and salt water, in humid earth, peat-bogs, and morasses. Our remarks will be limited to the living species contained in the group to which the reader's attention was first directed.

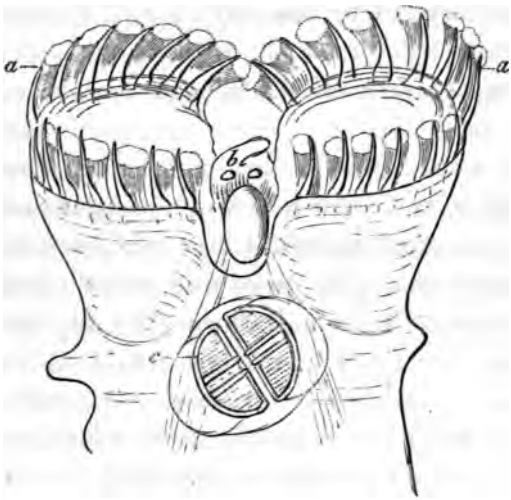
VIBRATILE CILIA.—As these processes are common to the whole class of Infusoria, and only differ in the several types in number, position, and relative magnitude, it is desirable, in this place, to give a more particular account of these remarkable instruments, which recent discoveries have shewn to exist also in the internal organs of man, and of the other vertebrated animals, and to be the agents by which many of the most important functions of the animal economy are performed.

These delicate filiform appendages, appear like very minute hairs rapidly vibrating in the water, and are only discernible by the aid of a good microscope. They are constantly performing a rotatory or circular oscillation; and, as there is a bulb at the base of each cilium, it is

supposed that a slight degree of tension on the bulb causes rotation at the base, and a more extensive motion at the extremity of the cilium, which thus describes in its revolution a cone, whose apex corresponds with the bulb. As we cannot separate the idea of muscular fibre from animal motion, it is conjectured that the cilia are impelled by definitely arranged muscles; and Ehrenberg believes that he has detected muscles, and even the disposition of their fibres, in some of the larger Infusoria.

In this group of *Vorticellæ*, (*see* pl. III, fig. 3), the cilia are seen in rapid motion, and occasioning currents in the surrounding fluid; and, as this *Stentor*, (pl. II, fig. 13), traverses the water, the particles of foreign matter near it are agitated by the eddies induced by the vibrations of its cilia; and in the *Rotifer*, (pl. XII, fig. 3), the currents are still more distinct, and are seen to run to and from the mouth of the animal; we shall have occasion to revert to this phenomenon hereafter. The cilia are so minute, that, even with the highest magnifiers, their figure, position, and the direction of their motions can alone be detected: their internal structure has hitherto eluded observation. They are most distinctly visible when almost all the water from the slide has evaporated, and left the animalcules nearly dry: the cilia are then elongated to their utmost extent, and in strong action.

The subjoined sketch of the cilia on the rotatory organs of the common Wheel-animalcule, (*Rotifer vulgaris*), hereafter described, copied from Ehrenberg, will illustrate the above description. The cilia (*a*, *a*) are here represented as shewn by the highest powers of the microscope.



LIGN. 1.—*The Upper Part of the Body of the* ROTIFER, *or* WHEEL ANIMALCULE, *highly magnified.*

a, *a*, The ZONES OF CILIA. *b*, The PROBOSCIS, bearing the TWO EYES.
c, The JAWS AND TEETH.

VIII.

THE MONADS.

Plate II.

In the group under the microscope, some minute points, or globules, of various colours, may be observed gliding rapidly along in various directions: these are called Monads. A few have been transferred to a drop of water, and, to distinguish their true characters, we must view them with glasses that magnify from 300 to 400 times in linear dimensions. We may now perceive (*see* pl. II, figs. 3, 7), that each individual is an oval or spherical transparent cell, containing granules, or little specks, of some coloured matter. Some are without eyes, or any sensible organs but the cilia, and one or more filiform spines or bristles, (pl. II, figs. 4, 5, 8); others have a red eye-speck, (*ocellus*); and many have indurated cases or shells. They vary in size from one *two-thousandth* to one *three-thousandth* of a line in diameter: a drop of water may, therefore, contain 500,000,000. Some are of a bright green colour, (*Monas grandis*); others pink, red, yellow, bluish, ochreous, (pl. II, figs.

4, 6), &c.; and the floating coloured slime which sometimes appears in the water, is an aggregation of countless hosts of these beings. One species, which is of a hyaline (glassy or crystalline) appearance, (*Monas crepusculum*), and but one two-thousandth of a line in diameter, is of a spherical form, and is said to be carnivorous; whitish masses, visible to the naked eye, are often formed by the accumulation of innumerable myriads of this species. The Monads never vary in form, whether they are in motion or at rest. They increase by self-division either into two, or four, parts, (pl. II, figs. 3, 7). When this process is about to take place, the granules within the integument, or case, seem to be divided by a transverse line: this gradually becomes more apparent, and at length the containing case itself contracts along the course of this line, and the monad appears double, (pl. II, figs. 7 *b*, 8). Both parts now have an impulse to separate, and an entire division soon takes place: the two become perfect individuals, and swim off in opposite directions.

In the CLOAK MONAD, (*Chlamidomonas*), this interesting process is beautifully exemplified. Fig. 7, shews a single animalcule, and another dividing into two: and in fig. 3, two Monads are seen separating into four. The same process in another species, (*Monas vivipara*), is represented in fig. 8.

The monads we have just examined are single, free animalcules; but others of the same family are either permanently or temporarily attached to a case, or support, in definite groups.

I. The GONIUM, or *Tablet Monad*, (pl. II, fig. 2).—This flat, quadrangular, hyaline body, studded with sixteen bright green spots, is a group of individual monads attached to a common tabular case, or support. If we view this group with a power magnifying 400, we perceive that each of the green spots is an animalcule furnished with two horns, and six little processes that pass off from the margin, and by which it is connected with its neighbours, (pl. II, fig. 2 *a*). The mode of increase in these clusters is exceedingly curious. A simple crucial division takes place in the case, or support, which is thus divided into four portions, each containing four monads: these rapidly subdivide into sixteen, the normal number; and so the process goes on, *ad infinitum*.

In the Gonium we have an example of the partially separated monads continuing in organic connexion, and always forming definite groups of individuals. This fact will prepare us for the examination of a common but most remarkable type of these animalcules, the *Volvox globator;* which is that revolving semi-transparent orb,

dotted all over with green spots, and fringed with cilia, now in the field of view, (pl. II, fig. 10).

II. The VOLVOX, or *Revolving Monad*, (pl. II, figs. 9, 10, 11, 12).—The *Volvox globator*, or Globe Volvox, was discovered 150 years ago by Leeuwenhoek, and was supposed to be a single animal, until the recent improvements in the microscope revealed its true character, and shewed it to be composed of a group of monads, fixed in a globular integument, or case, each little green point being a perfect and isolated individual, in organic connexion with the case and the surrounding monads. By a power of 500 the globe is shewn to consist of a family of polygastric animalcules, uniformly distributed over the spherical integument. Fig. 12, pl. II, represents a part of the globe highly magnified: in the centre is seen a group of six individuals, produced by spontaneous fissuration. The monad of the Volvox, (pl. II, fig. 11), has a red eye-speck, two long spines or horns, and six processes by which it is connected with its kindred animalcules. The little globular cells of the digestive organs are distinctly visible. In fact, we have here numerous perfect monads, partially imbedded in, and distributed over a hollow spherical carapace, or case, instead of on a tabular one as in the Gonium.

The Volvox increases by spontaneous fissuration, like

the other monads, but it presents an extraordinary peculiarity. If we look attentively at the large Volvox now slowly revolving through the water, bristling with long filaments, which are the protruded horns of the monads, (pl. II, fig. 10), we may discern within the globe several lesser ones, apparently differing from the outer globe only in size: these are new generations ready to escape, and go through the same changes as the parent group. These internal globes of young Volvoces are produced, in consequence of the spontaneous division in this species of monad, taking place only from the inside of the globular envelope. New spherical groups are thus thrown off *into* the cavity of the parent carapace, where they remain till they attain a certain stage of development. Some part of the integument of the outer globe then gives way, (*see* pl. II, fig. 9), and the young ones escape, and commence their independent existence. The internal globes are generally six or eight in number, but occasionally as many as twenty occur; they are green, have an entire margin, and may sometimes be seen to move while within the primary globe. There are apertures by which the water has free access to the interior of the whole series. The revolving motion of the Volvox, by which it is propelled through the water, is effected by the incessant action of the vibratile cilia, and is automatic, (that is, an organic or involuntary

action), by which means the aëration of the tissue and fluids is effected, the whole mass brought into contact with fresh portions of water, and the colony of monads transported from place to place; and thus supplies of food are constantly obtained.

III. The VIBRIO, or *Trembling Animalcule*, (pl. II, fig. 1). —Some extremely fine hair-like bodies are seen moving near the Volvox; these are groups of the polygastria termed *Vibrio*, of which several species are commonly present in water containing other animalcules. But little is known of their structure, in consequence of their extreme minuteness; for each filiform body is not an individual, but a series of many, united together in a flexible chain, from imperfect spontaneous transverse division. This chain is straight when motionless; and locomotion is performed by successive rapid undulations, (*see* pl. II, fig. 1).

IX.

THE VORTICELLINA, OR BELL-SHAPED ANIMALCULES.

Plate III.

THE object next to be examined is a portion of the mucus, or jelly, that we observed adhering to the sprig of the aquatic plant when first brought under our notice, (*see page* 9). Viewed with a moderate power, this apparent film of jelly is found to be composed of clusters of living animalcules, of very elegant forms. One part resembles a minute shrub, (pl. III, fig. 1); another portion consists of groups of bell-shaped cups, suspended by threads, or filaments, (pl. III, fig. 3); and, associated with these fixed groups, are several free animals, of the same general configuration, which are traversing the water in various directions, (pl. II, figs. 13, 15). All these animalcules are Polygastria, distinguished from those previously described by the cilia being arranged around the region of the mouth, or aperture for the food, and by a peculiar modification of the digestive canal. In these Infusoria the body is either of a funnel, or bell-like shape, having the upper border

garnished with one or more zones of cilia; these organs being in most of the species limited to that region, and not diffused generally over the body, as in the monads. They increase by spontaneous division and gemmation, and are destitute of a sheath, or carapace. We have species of three genera before us.

I. The STENTOR, or *Trumpet Animalcule*, (pl. II, figs. 13, 14, 15, 16).—The animalcules now in view, and which are seen in different attitudes, (pl. II, fig. 14), are called *Stentors*. There are several species, some of which are of a rose colour, others blue, green, (pl. II, figs. 13, 14), &c. They are comparatively of a large size: one species (*Stentor Mulleri*) is half a line in length, and therefore visible to the naked eye. The body of one species is garnished with cilia, and has a crown of larger cilia around the aperture, which is spiral. The Stentors have no pedicle, but they can fix themselves by the point of the base. They transport themselves through the water with rapidity, by means of their coronets of cilia. They are very voracious: in the body of one specimen may be seen several monads, which it has swallowed, (pl. II, fig. 13).

The Multi-shaped Stentor, (*S. polymorphus*), is of a green colour, and varies its form greatly in different

positions, (pl. II, figs. 14, 15). This animalcule often occurs in immense numbers, appearing like a crust of jelly on the stems and twigs in the water, (*see* pl. II, fig. 16).

The BLUE STENTOR (pl. II, fig. 13) has a longitudinal crest, or ridge, extending down the side of the body, (pl. II, fig. 13 *a*).

II. The BELL-SHAPED ANIMALCULES, or *Vorticellæ*, (pl. III).—These are the most common, and at the same time the most elegant, of the Polygastria. They are met with in clusters of myriads, attached to leaves, twigs, roots, or other bodies in the water. They quickly appear in vegetable infusions; and the transparent mucus observable on aquatic plants, and in vessels containing infusions, will generally be found to consist of some species of this genus. They are often attached in clusters to the shells of the small Crustaceans (*Monoculus, Cyclops,* &c.) that abound in the water. The common *Water-Flea* is frequently infested with them, and may be seen swimming about with groups of Vorticellæ affixed to its case.

The body of these elegant creatures, (pl III, fig. 3), is bell-shaped, and has a coronet of cilia on the upper border. The margin of the cup, or bell, is enlarged and

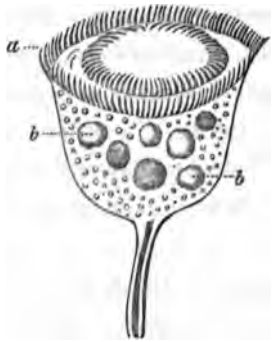
projecting. From the middle of the under part, a long tendril, or spirally contractile pedicle, or stalk, proceeds, and is fixed to a common base, with numerous other individuals,—the whole forming a group, or cluster. The size of the body, without the stalk, is about one twenty-fourth of a line. The pedicle by which the body is fixed to its position, is furnished with a long muscle, by means of which it can be suddenly contracted into a spiral coil, apparently at the will of the animal, (pl. III, fig. 3); the Vorticella has thus considerable latitude of motion, though restrained within the limits of its tether. This contractile action is continually going on,—now in one or two individuals only, then in several; and often the whole group suddenly shrinks down into a confused mass, and the next instant expands, and every little bell becomes fully developed, with its cilia in rapid oscillation.

VORTICELLÆ FED WITH CARMINE, (pl. III, figs. 1, 2, 3, 4, 6). The circular eddies, or whirlpools, produced in the surrounding fluid by the zones of cilia are visible in ordinary conditions; but they are rendered much more distinct if a few particles of colouring matter are introduced into the water; and by this means another interesting part of the structure of these animalcules is made manifest. Let us try the experiment. I place

a drop of a solution of carmine* in the water between the plates of glass containing the Vorticellæ: the fluid in which they are floating now appears turbid, and full of grey particles, which are thrown into rapid motion by the vibrations of the cilia, and currents are seen passing to and from the mouth of the animalcules. In a few minutes the water gradually becomes clear, and several round spots of carmine are apparent in the body of each of the Vorticellæ, (pl. III, figs. 3, 6). We have, in fact, caused their little stomachs to be filled with colouring matter, and can now distinguish their number and arrangement. If the body of the Vorticella were a mere vase or cup, or a simple cavity like the digestive sac of the Polype, it is obvious that the carmine must have collected into a single ball or mass; but this is not the case; on the contrary, the colour appears in distinct round spots, from having accumulated in globular cells; and, by careful investigation, the tube connecting these cells may be detected.

* Sap-green, indigo, or carmine may be employed; it is necessary to use colour free from adulteration. The idea of colouring the water containing animalcules, with the view of rendering their transparent organs more distinct, originated with M. M. Trembley and Gleichen; but no important results were obtained by the experiments of these observers. In the hands of M. Ehrenberg this method of investigation proved eminently successful, and led to the discovery of the internal structure of the Polygastria.

The highly magnified view of a single Annulated Vorticella, (*Vorticella convallaria*), in the annexed lignograph, very distinctly displays the zones of cilia, and the globular stomachs.



LIGN. 2.—*A detached* VORTICELLA CONVALLARIA, *highly magnified.*

a, The CILIA. *b*, *b*, The GLOBULAR STOMACHS.

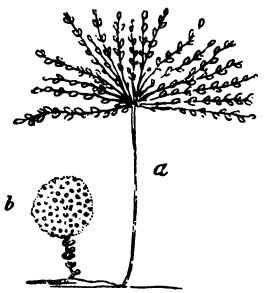
The Vorticellæ, like the Monads, increase by self-division. A fissure begins to extend through the longest diameter of the cup, and continues till it is completed, (pl. III, fig. 2), the two portions in the meanwhile rapidly acquiring the perfect form of the species. A fringe of cilia next appears round the base of each, (pl. III, fig. 3 *a*, and fig. 4), and the bodies then separate from the pedicle, which soon perishes. The liberated

Vorticellæ roam free for awhile, and at length throw out a fresh pedicle, become fixed, and ultimately produce another colony of individuals by spontaneous fissuration.

III. The ARBORESCENT VORTICELLA, (*Carchesium*, pl. III, fig. 1).—In some kinds of *Vorticellina* the pedicle, instead of being single down to its attachment, springs from a common trunk, the individual bodies hanging at the extremities of the branches like the flowers of the harebell: this results from imperfect self-division. In this species, the group commences by a single Vorticella dividing longitudinally into two portions, and thus producing two perfect individuals, which are connected by a forked stem: these two divide into four, which, in like manner, are united by their pedicles; and so the process goes on, till the limits of this special type of development are reached. In pl. III, fig. 2, is shewn the manner in which the longitudinal fissuration takes place. Two distinct cups or bodies are formed, and are seen in progress of separation: each is provided with a distinct set of cilia and digestive organs, as denoted by the coloured spots in each bell: in a short time the division would be completed, and each animalcule supported on a pedicle. The body of this animalcule, when arrived at maturity, separates from the parent

stem in the same manner as the former species, traverses the water in freedom for awhile, and then becomes fixed, and goes through the allotted phases of its existence.

In another kind of *Carchesium*, the stem is also spirally contractile, and branched by imperfect self-division, and the clusters appear like miniature trees or shrubs.



LIGN. 3.—THE CARCHESIUM, *or* TREE VORTICELLA.

a, The Group expanded. *b*, The whole Group contracted into a globular mass.

One of these groups is here represented, as seen with a low power; it is shewn extended in fig. *a*, and contracted into a ball, in fig. *b*.

PHYSIOLOGICAL SUMMARY.—In this rapid survey of the *Polygastria* contained in the drops of water under review, the principal characters of this class of animal-

cules have been exemplified. The digestive organs consist of a series of globular stomachs, connected by a common tube, which allows entrance to the food, and exit to the effete particles. The food is brought to the mouth by the currents produced in the water by the cilia; aeration is performed by the agency of the same organs; and the increase of the species is effected by spontaneous division, each part, like the severed portions of the polype, quickly growing into a perfect individual. Some are fixed to one spot in youth, but become free when arrived at maturity, and are thus capable of transporting themselves through the water to localities possessing the conditions required by their organisation.

There are proofs of a muscular system, however simple, in the motions of the cilia, and in the rapid contractions and changes of form which are exhibited in certain species. No definite nervous system has been detected, but there can be no doubt that a nervous influence is diffused through their structures; and the existence of an eye-speck, or visual point, however rudimentary, denotes a distinct nervous centre*. Eyes

* "There must, therefore, be nerves or conductors of that influence for the various movements, whether we consider them as voluntary, or *reflex*, that is, induced by stimuli, either within or without the body, upon the contractile fibre."—*Professor Owen.*

have been observed in fifty species: the colour, or pigment, is in most instances red, but in one genus it is black.

The Polygastria, when examined at night, are found to be moving as actively as in the day; in fact, they seem never to require repose; a phenomenon difficult to be explained, unless we assume that their actions are automatic, or involuntary.

In the next division of animalcules, we shall find a marked difference, both in structure and habits. The increase of the species is no longer effected by spontaneous division or fissuration; the organs of digestion are less numerous, and of a higher type; and, though locomotion is performed by cilia, the position and arrangement of these instruments are considerably modified.

X.

THE ROTIFERA, OR ROTATING ANIMALCULES.

THE term ROTIFERA, or *Wheel-bearing Animalcules*, by which this class is distinguished, refers to the appearance assumed by the zones, or circular rows of cilia, around the upper part of the body, when rapidly vibrating; and which so closely resembles that presented by the rotation of a wheel, that every one who sees the phenomenon is struck with the similitude. The resemblance is heightened by the wavy or undulating motion by which one cilium is carried out of sight, while the next is visible; for this alternate presence and disappearance of the image contributes to the optical illusion. The cilia do not occur on any other part of the body, as in the Polygastria; the semblance of such processes on some of the larger Rotifera is produced by parasitic plants*.

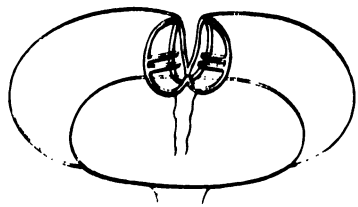
The ROTIFERA possess a definite form, and rotators formed of cilia; many species have a false foot, or pedi-

* Ehrenberg.

cle. The rotatory organs are rows of cilia, placed on circular or semi-circular eminences on the upper part of the body. In some species, the cilia are in a single series; in others, in several rows of different forms: and in one genus, (*Stephanoceros*), they assume the character of ciliated tentacula, rather than that of simple vibrating processes. There are distinct muscles for the internal and external movements. In some species, the pedicle has a sucker at its extremity, which serves to fix the body during the rapid motions of the rotators; and, without this power of attachment, the upper part of the body would be drawn in by the action of these organs. The digestive canal is a tube more or less straight, which in many genera is provided with jaws and teeth: these, like the masticatory organs in birds, are situated low down, are very distinct, and present considerable diversity of form and arrangement.

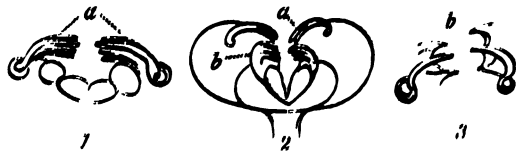
Masticatory Organs of the Rotifera. — The reader, from what has already been submitted to his notice, is familiar with the marvellous powers of the microscope, or he would probably receive with some degree of scepticism the following account of the jaws and teeth of animalcules, none of which exceed two-thirds of a line in length, and are, therefore, but just perceptible to our unassisted vision.

jaws of the Rotifer (ligns. 1 and 6) and of the Floscularia, (lign. 5, fig. 1).



Lign. 6.—*Jaws and Teeth of the* Rotifer, *highly magnified.*

In other species, with the same type of masticatory apparatus, the jaws are furnished with several teeth; as in the *Stephanoceros*, or Crowned Animalcule, in which there are two distinct sets of teeth on each side, as shewn in the annexed figures.



Lign. 7.—*Jaws and Teeth of the* Stephanoceros, *highly magnified.*

Fig. 1. The Upper Set of Teeth, marked *a*, in fig. 2.
Fig. 2. The Double Set of Dental Organs, in their natural position.
Fig. 3, The Lower Set of Teeth, marked *b*, in fig. 2.

Respiration, or, more properly, the aeration of the fluids, is effected in the Rotifera by the constant introduction of fresh water through one or more aper-

tures near the neck, (*see* pl. XII, fig. 3, *c*); and in some kinds there are internal oval bodies, composed of granules, or corpuscles, which have constantly a tremulous motion, and are supposed to perform the office of *branchia*, or gills.

There are indications of nervous centres, or *ganglia*, in several genera; and from one to four punctiform eyes have been observed in 150 species: in some there appears to be a ganglion, or nervous mass, immediately beneath the eye. Some kinds are oviparous, others viviparous. An elongated bag or sac, in which the ova, or eggs, are formed, is distinctly visible; but few eggs are developed at the same time. The ova, in many species, equal in size one-third of the body of the animalcule. They retain their vitality for almost an unlimited period, and are transported by the water, and wafted by the winds—for, whether dry or moist, they remain uninjured—till, thrown into the conditions suitable to their organisation, they become developed, and the apparently pure waters suddenly teem with myriads of highly organised beings. Even the adult animals of some species—the common Rotifers, for instance—after being apparently dried up for several years, will start into life upon the addition of a few drops of water, and throw their rotatory organs into full play, as if roused from a refreshing slumber.

XI.

THE FLOSCULARIA, OR FLOWER-SHAPED ANIMALCULES.

Plates IV, V, VI, VII, VIII.

THE Rotifera we shall first examine have one simple, continuous, rotatory organ, the margin of which is more or less deeply lobed, or undulated. The body is inclosed in a cylindrical case, or sheath, which is fixed at the bottom, and open at the upper extremity, from which the rotator and upper part of the body can be protruded. This family is named *Floscularia*, from the flower-like appearance of the body when expanded; it comprises six genera, in which are some of the most interesting animalcules of the whole class.

I. The LIMNIAS, or *Water-Nymph*, (*L. ceratophylli*, pl. IV).—Here is a group of eight individuals, accidentally clustered together, of the *Hornwort Limnias**, an animalcule with an isolated tubular sheath, into which it can

* So named, because often found on the plant called Hornwort, or Ceratophyllum.

retreat and wholly conceal the body, when the water is agitated; as shewn in pl. IV, *a*. The rotator, which is fringed with cilia, and divided into two lobes, presents a highly interesting spectacle when fully expanded; as in pl. IV, *b*. The tube, or sheath, is at first clear and transparent, but becomes of a yellowish brown colour; and is frequently coated with foreign matter, which adheres to its viscid surface. In the young state the Limnias has two eyes, that disappear with age. The length of the sheath and body is from one-half to two-thirds of a line, and therefore recognisable by the naked eye. The jaws and teeth are of the type figured page 55, fig. 1; but they cannot be seen in the example before us, which is a remarkable cluster of several individuals of various ages. Four or five eggs are perceptible within the tube of the largest animalcule, (pl. IV, *c c*).

II. The MELICERTA, or *Honey Floscularia*, (pl. V).—This is a tubular animalcule, about two-thirds of a line in length; it differs from the Limnias, in having the rotatory organ divided into four lobes, the two uppermost of which are the largest. The species before us is the BEADED MELICERTA, (*M. ringens*), so called from its case being made up of little corpuscles, which give it a granulated, or beaded character. Its body is hyaline,

(that is, of a crystalline appearance). The sheath is isolated, granular, and of an elongated conical form, and is composed either of lenticular, hexagonal, or pentagonal bodies, produced by a viscid exudation from the base of the animal, that hardens in the water. The envelope of the body is at first transparent, the granular coat being of subsequent formation. If the newly-hatched young are put into water, and a drop of a solution of carmine or indigo be added from time to time, the case will be party-coloured; for zones of red or blue globules will be formed, alternating with white; as in pl. v, fig. 5. A very young example is seen, fig. 3, with but one ring of corpuscles, which is coloured by the carmine: in figs. 2, 4, the same individual is represented when of more advanced age, and the sheath consists of several zones of corpuscles.

The young has two eyes, which disappear in the adult.

Near the neck there are two respiratory tubes, (pl. v, fig. 5, *a a*), which are very prominent in the young state.

The Melicerta, like the Limnias, is an exceedingly susceptible animal, concealing itself within its case upon the slightest agitation of the water. It is a beautiful object when its rotatory organ is fully spread out, and the cilia in rapid motion.

III. The FLOWER-SHAPED ANIMALCULES, or *Flosculariæ*, (pls. VI, VII, VIII), properly so called, are very elegant types of the family, and are distinguished by the peculiar character of the rotator, which is divided into more than *four* lobes. In this beautiful species, the ELEGANT FLOSCULARIA, (*F. ornata*, pl. VI), the sheath is hyaline, and the rotatory organ consists of six lobes, armed with very long cilia. The body is capable of being protruded beyond the case almost to its base, (pl. VI, fig. 1), and can be drawn in so as to include the cilia, (pl. VI, fig. 2), in which position the sheath is corrugated in circular folds. From the transparency of the sheath and body, the internal organs are distinctly visible. The jaws and teeth (*see* pl. VI, fig. 1, *a*, and lign. 5, fig. 1) are seen beneath the pharynx, or constriction of the alimentary canal, and several Monads and other minute polygastrians in the stomach, (pl. VI, fig. 1, *b*). A young one, with two red eyes, is visible in the ovisac, (fig. 2, *c*). In another example, (pl. VII), the body is partially protruded over the top of the sheath, within which are three well-developed eggs.

IV. The other species under the field of view, the HORNED FLOSCULARIA, (*Floscularia proboscidea*, pl. VIII), has the rotator divided into six lobes, with shorter cilia than in *F. ornata*, and these surround a horn, or proboscis,

which is also armed with cilia, (pl. VIII, *a*). This animalcule is about two-thirds of a line in length; the sheath, one-third of a line; and the egg, one twenty-fourth of a line.

XII.

THE STEPHANOCEROS, OR CROWNED ANIMALCULE.

Plates IX, X, XI.

THIS is an exceedingly interesting animalcule, from one-half to one-third of a line in length, and is generally found attached to the stem, and under surface of the leaves, of the Water-lily, and other aquatic plants*.

* Having seen the figures of the *Stephanoceros* in the splendid work of M. Ehrenberg, I was very desirous of obtaining living specimens for examination, not being then aware that this animalcule had already been collected in England by Mr. Dalrymple.

Mr. Hamlin Lee, at my request, undertook to search for it in the pools and streams on Clapham Common, and, after several weeks' diligent examination of the aquatic plants in various localities, he obtained, in October, 1842, several individuals on the leaves of the *Nymphea alba*, growing in the lake behind Grove House—a most prolific locality for all kinds of fresh-water Infusoria. It has since been found in other ponds, and particularly in that called the *Black Sea*, on Wandsworth Common, near the railway station. It is comparatively rare, and the past summer has been remarkably unfavourable for its development, but few examples having been observed even in its favourite haunts. While living at Clapham Common, we were always able to keep a stock of the Stephanoceros in glass jars with water containing aquatic plants; but at my

The STEPHANOCEROS appears under the microscope like a cylindrical vase, as clear as crystal, surmounted by a crown formed by the convergence of the points of five long arms, or tentacula, each fringed with about fifteen rows of delicate, short, verticillate cilia, which are in constant oscillation, (*see* pl. IX). The vase contains several bodies of different colours: these are the internal organs, and the Monads and other polygastrians that have been swallowed. The rotatory organ in this animalcule is wholly unlike that of any other of the class. It is deeply divided down to its base into five long processes, which may be regarded as ciliated tentacula, for they are flexible and prehensile, and employed by the animal to retain the prey brought within the vortex produced by the vibrations of the cilia. The arms are, however, limited in their action, and, so far as my observations extend, do not appear capable of being lengthened and shortened, or of bending outwardly and laterally, like the tentacula of the Hydra*.

present residence the attempt to preserve these animalcules alive, even for a few days, has been unsuccessful, and the eggs have in no instance reached maturity. As the precaution was taken to supply them with water from their native lakes, the mortality must be ascribed to some local condition of the atmosphere. The descriptions in the text refer to observations made in 1843 by me and my late assistant Mr. H. Lee, now Conservator in the College of Surgeons of Edinburgh.

* From these ciliated arms, which are arranged around the mouth as

The transparent case, or mantle, which invests the body of the Stephanoceros, is not an open rigid tube, as in the Melicerta, but a flexible integument, which is thrown into annular folds or corrugations when the animal contracts itself; and, as the upper margin of this mantle is attached like a collar round the body, near the base of the rotators, its border becomes inflected when the animal shrinks down towards the bottom of the case, (*see* pl. IX, fig. 2), the tube being then like the introverted finger of a glove. In this position the tentacula are brought close together, side by side; and when the creature is about to protrude, the extremities of the arms first appear united into a point, which gradually lengthens, till the rotatory organs are wholly excluded, and assume the form of an elongated dome, the base of which surrounds the mouth. In some positions the crown is depressed, and resembles in shape the cupola of a mosque. From the different phases assumed by the Stephanoceros, and its constant activity when vigorous,—for it will shrink into its crystal cell the in-

in the marine polypes, (the *Bryozoa*, or moss animals, so named from their investing other bodies like moss, of which the common *Flustra* is an example), the Stephanoceros may be regarded as the link which unites the *Rotifera* with the *cilio-brachiate* (*arms with cilia*) polypes. The manner in which the arms of this animalcule are protruded and withdrawn, will remind the experienced observer of the similar action in the Flustræ, &c.

stant the stage of the microscope is slightly struck, and as quickly reappear and vibrate its cilia,—and the interesting internal phenomena it presents, it is an object of all others the most calculated to arrest the attention, and gratify the curiosity of the general observer, as well as of the accomplished naturalist*.

The Stephanoceros has a single red *ocellus*, or eye-speck, in its young state; and there are near the base of the rotators two minute round bodies at the origin of each arm, (pl. IX, fig. 1, *a*), that are supposed to be *ganglia*, or knots of nervous matter. On each side the body, in every specimen that came under my examination, a dark oval granular mass was observable, (pl. IX, fig. 1, *b*), which, seen with a high power, appeared to consist of corpuscles that were always in tremulous motion. These bodies would sometimes spread out very considerably while under view, and the corpuscles were then more distinct and less closely aggregated. These

* There will be found considerable discrepancy between the description in the text, and the figures of *Stephanoceros Eichornii* given by M. Ehrenberg, and repeated by M. Mandl, (*Traité pratique du Microscope*. Paris, 1839). The Clapham Stephanoceros is probably either a different species or variety. If it should prove to be specifically distinct from the Prussian Stephanoceros, I would propose to name it *S. Ehrenbergi*, as a tribute of respect to the illustrious philosopher, whose labours have so largely contributed to the advancement of physiological science.

organs probably perform the function of gills, or *branchiæ*.

There are visible muscles, by which the motions of the body are effected. The stomach is ample, and situated immediately beneath the mouth: it generally contains Monads and other minute Infusoria, (pl. IX, fig. 1, *d*). There are two jaws, armed at their extremities with four free teeth, the action of which is very discernible, (pl. IX, fig. 1, *c*, and lign. 7, p. 56), and it is amusing to watch the movements of these dental organs when tearing the food. Ehrenberg mentions having seen a Stentor grasped by the tentacula; and I once witnessed a similar capture.

The Stephanoceros is ovo-viviparous; that is, it increases by eggs which are hatched ere they escape from the sheath. A cluster of eggs may generally be seen in the ovisac, and one or two advancing to maturity, (pl. X).

THE DEVELOPMENT OF THE YOUNG IN THE STEPHANOCEROS.—As the progressive development of the eggs and young of the Stephanoceros has not, I believe, been made the subject of accurate observation, I shall here introduce a few particulars which came under my notice when investigating the organisation of this animalcule in the spring and summer of 1843.

In several individuals one or two enlarged ova were perceived, and these were situated on the side of the body, (pl. x, *e*, *e*). The first perceptible change was the gradual appearance of a dark nucleus in the largest egg, (pl. x, fig. 1, *e*), which increased till it occupied the whole of the cavity, except a narrow pellucid border, (pl. xi, fig. 4, *f*). A slow semi-rotatory motion now became manifest in the inclosed embryo, which in a few hours assumed a definite shape, appearing like a soft, elongated, coiled up body, the head being bent over the other extremity, (pl. xi, fig. 4, *g*). The movements of the embryo soon became more frequent and powerful, till at length the egg burst, and the young animalcule escaped into the cavity of the sheath, (pl. x, fig. 2, *h*). In this stage it was of an elongated conical figure, having the largest extremity fringed with cilia, and might readily have been mistaken for a Stentor, or similar polygastrian. The young one, in the instance described, made its way to the bottom of the sheath, from which, at the expiration of three hours after its liberation from the egg, it escaped, and swam freely in the surrounding water*.

* In another individual, according to the observation of Mr. Lee, the young one (from the uppermost egg, pl. x, fig. 1, *e*) escaped from the upper extremity of the sheath, near the base of the rotatory organ.

Thirty hours after its liberation from the sheath of the parent, the young Stephanoceros maintained the same general appearance: but it had increased in size, the cilia were larger, and their action more powerful; and a cluster of four (or five) sub-conical papillæ was perceptible within the body, (pl. xi, fig. 1, *a*); these were probably the rudimentary rotatory organs. Eighty hours after birth the young creature, when partially contracted, appeared as in pl. xi, fig. 2. The five mammillated projections fringed with cilia, (four only are shewn in this aspect), on the upper margin, are evidently the rudiments of the tentacula. The position of the stomach is indicated by the green colour of the food that has been swallowed.

The development of this individual was traced no further; but in another, observed from its exclusion from the egg to the eighty-fourth hour, the arms were more produced, (pl. xi, fig. 3, *a*), and the digestive organs very distinct, (pl. xi, fig. 3, *b*). In this example the young one did not escape from the sheath: the parent died about ten hours after the egg burst, and its body soon decomposed. The young one continued to grow, though inclosed in the sheath, till the eighty-fourth hour, as shewn in pl. xi, fig. 3, when it expired. No traces of a sheath or mantle were observable in any of these specimens, nor was the red eye, described by M.

Ehrenberg, detected in the young upon which the preceding observations were made.

I was unable to watch the further progress of the young Stephanoceros. It is probable, that, after a short term of freedom, it becomes fixed by the base, and passes through successive stages of development to maturity*.

* The observations described in the text were made while suffering under a severe indisposition, which ultimately compelled me to abandon the investigation. It was my intention to renew it under more favourable circumstances, but, as this has hitherto been impracticable, this imperfect notice is inserted, in the hope of inducing other observers to follow up the inquiry.

XIII.

THE ROTIFER VULGARIS, OR COMMON WHEEL-ANIMALCULE.

Plate XII.

In the water first examined may be noticed several elongated leech-like animalcules, swimming about in every direction, now winding their way among the swarms of lesser beings, then fixing themselves by one end, and protruding from the other extremity two cups fringed with cilia, which appear to whirl round and round like a pair of wheels on their axes; or suddenly drawing in these organs, shrinking up the entire body into a globular opaque mass, and leaving no part of their internal organisation visible. These creatures are the Wheel-animalcules, commonly so called, and were the first species of the Rotifera that attracted the attention of the early observers*.

* The *Rotifer vulgaris* was first figured and described by Leeuwenhoek in 1702; and more fully by Baker in 1744. See "Employment for the Microscope," pl. xi, p. 288, ed. 1785.

The family to which they belong* comprises the Rotifers which are furnished with a pair of simple, nearly circular, wheel-like rotators. The body is either cylindrical, fusiform (spindle-shaped), or vermiform, without a case or sheath, but capable of contracting into a globular mass by the involution or withdrawal of the upper part of the body into the lower, somewhat after the manner of a telescope. There are many species, which are arranged in seven genera; most have eyes, and discernible internal muscles. The species before us (pl. XII) will suffice to afford a full illustration of the organisation of this interesting group of animalcules; and as it is abundant in every pool and stream, in every phial containing water with decomposing vegetables, and may even be obtained from the dry sediment in leaden troughs, the reader, whose curiosity is awakened by the following remarks, may readily procure specimens for examination.

The COMMON WHEEL-ANIMALCULE, (*Rotifer vulgaris*, pl. XII, fig. 3), is from one-quarter to one-half of a line in length: its body is of a whitish colour and fusiform shape, that is, largest in the middle, and tapering towards the ends, the tail part being the smallest. In the middle of

* *Philodinea* of Ehrenberg.

the upper extremity of the body there is a protuberance, or trunk, on which are two round red eyes placed on ganglions, and a soft eye-speck. On each side this trunk is a rotator, consisting of a semicircular cup fringed with strong cilia: these organs are commonly called the *wheels*. There is a respiratory tube, for the free passage of water to the interior. The lower extremity of the body is furnished with a tail having six points when expanded. The upper part of the alimentary canal has a constriction or pharynx, which is surrounded by four hemispherical muscular masses, placed opposite to each other in a crucial position; and these are very manifest when in action. The pair of jaws, with teeth, are of the type figured and described in p. 56, and may be distinctly seen even in the embryo. The nature and relative situation of these several parts will be best understood by reference to a highly magnified view, by Ehrenberg, of a Rotifer with the wheels displayed, and of which pl. XII, fig. 3, is a reduced figure.

a, The trunk or proboscis on which the eyes are placed.

b, *b*, The rotatory organs, or wheels. The spiral course of the eddies induced in the water by the action of their cilia is indicated by the arrows.

c, The respiratory tube.

d, The jaws, armed with teeth.

e, The digestive organs coloured by a solution of carmine swallowed by the animal. The direction of the currents to and from the mouth, occasioned by the cilia around the entrance of the alimentary canal, is shewn by the colour.

f, Four bundles of long internal muscles, by which the body is contracted and extended.

g, An egg in the ovisac, containing an embryo, in which the eyes and jaws are discernible.

h, The tail, or pedicle.

Of the organs above pointed out, the rotators are those which always excite most surprise; for, notwithstanding what has been stated in explanation of their true nature and action, the inexperienced observer will find it difficult to divest himself of the idea that they actually do move round like wheels, for they appear to revolve continuously in one direction, because one set of the vibratory movements of the rows of cilia is alone perceptible, (*see* lign. 1, page 35). Each rotator has from fifty to sixty fine cilia, which when vibrating form twelve or fourteen groups: each cilium swings round on its base, producing a motion like the rotation of the human arm. When any colouring matter is introduced into the water, the directions of the currents caused by the cilia are very manifest. Those produced by the rotators are gyratory; those by the orifice of the mouth

(indicated by the colour, pl. XII, fig. 3) are seen passing down to the stomach; and at the constriction, or neck, the particles may be traced in a continuous line from the mouth to the internal cavities. The motion of the rotators is voluntary: it can be instantly arrested, and the organs drawn out of sight, and again protruded, at the will of the animal. When the wheels are drawn in, while the body remains extended, and its trunk projecting, they appear like two flat semi-elliptical disks, immediately above the jaws, (pl. XII, fig. 4, *b*, *b*).

An individual fixed by its tail, and having its body much contracted, is shewn in pl. XII, fig. 7.

The Rotifer is oviparous, and eggs in progressive stages of development may generally be seen within the body. A young one just escaping from the egg is represented in pl. XII, fig. 5. The increase of this species is in a ratio almost incredible. Ehrenberg has ascertained, by direct observation, that from a single individual a million may be produced by the tenth day, four millions by the eleventh, sixteen millions by the eighteenth, and so on.

Such is the organisation of the Rotifer, as seen under a good defining power. The mode of obtaining these animalcules, and the varied appearances, and diversified shapes and attitudes which they assume, are

graphically described by Baker in the following extract:—

"If the water standing in lead gutters, or the slimy sediment it leaves behind, has anything of a reddish colour, one may almost be certain of finding the wheel-animals therein; and if, in summer, when all the water is dried up, and nothing but dust remains, that dust appears red, or of a dark brown, one shall seldom fail, on putting it in water, to disclose multitudes of minute reddish globules, which are, indeed, the animals themselves, and which will soon change their appearance; for in the space of half an hour a languid motion begins, the globule turns itself about, lengthens by slow degrees, and becomes in the form of a transparent caterpillar; and appears lengthening out its body considerably at some times, and contracting it as much at others. Its motion from place to place is likewise then performed in the manner of such creatures: fixing first its tail, and extending its whole body; then fastening its head, and drawing up its tail to it, (*see* pl. XII, fig. 6); and so on, by which it gets along pretty nimbly. But one shall often behold it changing this appearance in an instant, and assuming a form extremely different; for its snout being pulled somewhat inward, the front end becomes clubbed, and immediately dividing, exhibits most surprisingly to view a couple of semicircular instruments before unseen, round the edges whereof many little *fibrillæ* (cilia) move themselves very briskly; sometimes with a kind of rotation, and sometimes in a vibrating or trembling manner. An opening or mouth also appears in the middle between these two semicircles. When in this condition the animal is often seen to unfasten its tail, and swim along with a great deal of swiftness, seemingly in pursuit of prey. When the fore part of the creature first appears to open or divide, the instruments above described, which, when fully protruded, resemble a pair of wheels having a quick rotation, coming then but a little way beyond their tubular cases, and being in that condition like round pieces of paper folded in the middle, or funnels whose sides are flattened almost together, seem only like a couple of semicircular parts, about the edges whereof what are seen afterwards like the teeth of wheels appear only as little

spicula, having a nimble and continual vibrating motion upwards and downwards; whereby the water becomes greatly agitated, and is brought to the animal from several times the distance of its own length. As the creature is capable of thrusting out these wheels, or drawing them in as snails do their horns, the figure of them is different in their several degrees of extension or contraction, or according to their position to the eye of the observer*."

Resuscitation of the Infusoria.—Allusion has already been made to the extraordinary tenacity of life with which certain species of Infusoria are endowed,—a phenomenon which did not escape the notice of the early microscopists. That the eggs of the oviparous kinds should be found capable of development for a long period after their exclusion, would not excite much surprise; but that adult animals, possessing eyes, muscles, nerves, organs of respiration, &c., should revive after being dried up to dust, is a phenomenon so startling, as to require the most satisfactory evidence, before the possibility of such a resurrection could be admitted. The statement, with some limitation, is however unquestionably true; for though it is not to be supposed that any animal could revive if it were quite dried up, yet it is certain that some species of the Infusoria will remain in a dormant state for years, if buried in earth or sand apparently dry. Some Rotifers were alter-

* Baker on the "Employment for the Microscope," pp. 269—277.

nately dried and rendered dormant, and then revived by the addition of water, *twelve times*, appearing at each successive resuscitation as active as at first*. Professor Owen mentions having witnessed the revival of an animalcule, (a species of *Arctiscon*), which had been preserved in dry sand four years†.

* In this respect these animalcules resemble certain plants, whose tenacity of life is such, that they preserve their vitality, like seeds, for many years. Mosses that had been dried for a century have revived after immersion in water for a few hours.

† Hunterian Lectures for 1843, p. 40.

XIV.

ANIMALCULES WITH SHELLS.—THE BRACHIONUS, OR SPINE-BEARING ANIMALCULE.

THERE is yet one kind of animalcule undescribed, in the drops of water which have afforded us so many interesting objects for investigation. This belongs to the group of Rotifera which have their bodies protected by a firm sub-cylindrical shell, or carapace. Its form is that of a vasé, with a retractile forked pedicle proceeding from the base. There are two species under view, (pl. XII, figs. 1, 2).

I. The PITCHER-SHAPED BRACHIONUS, (*B. urceolaris*, pl. XII, fig. 1).—This species has a smooth shell, with six short horn-like processes, or spines, on its front part, and the lower end rounded. The body is white, from one-sixth to one-eighth of a line in length, and furnished on the upper part with a pair of lobed rotatory organs, composed of five portions. The jaws have five teeth at the free extremity, and may be regarded as dental hammers divided into sharp spines, which crush

the food upon the little block or anvil beneath, (pl. XII, fig. 1, *a*, and p. 55, lign. 5, fig. 2). This creature has one eye, which is quadrangular, a respiratory tube, and trembling organs (*branchiæ*) in the interior. It is oviparous, and the eggs are attached to the body till the young are hatched.

II. BAKER'S BRACHIONUS, (*B. Bakeri*, pl. XII, fig. 2). —The shell of the other species is scabrous or rough, with six unequal spines on the upper, and two very long lateral ones on the lower end; its jaws are shewn in p. 55, fig. 2, *a*.

These minute beings aggregate together in numberless myriads, so as to form whitish masses that float in the water; after the death of the animals the shells retain their form, and accumulate in layers at the bottom of pools, lakes, &c.

STRATA OF LIME AND FLINT FORMED BY INFUSORIA. —In many families of the polygastric Infusoria, the cases, or shells, consist either of lime, silex (flint), or iron; and these retain their form and structure for unlimited periods of time. From the inconceivable numbers of these shell-animalcules which swarm in every body of water, whether fresh or salt, and the immense rapidity with which the species increase—by spon-

taneous fissuration, gemmation, and ova—extensive deposits or strata of their cases are constantly forming at the bottom of lakes, rivers, and seas. Hence have originated the layers of white calcareous earth common in peat-bogs and morasses,—the tripoli, or polishing slate of Bilin, consisting wholly of the siliceous cases of animalcules,—and the bog-iron, composed of the ferruginous shields of other forms of Polygastria. In short, the extensive and important changes that have been produced on the earth's surface by this agency, in the earlier ages of the physical history of our planet, and those of a like nature which are going on at the present time, are in the highest degree interesting, and have but lately become the subject of scientific investigation*.

* For an account of fossil animalcules, see "Wonders of Geology," vol. ii, p. 798; "Medals of Creation," p. 215; and "Thoughts on a Pebble," 7th edition. *Vide Appendix.*

XV.

REFLECTIONS.

ALL the different kinds of animalcules contained in the water placed under the microscope at the commencement of our investigations having been examined, we will remove the glass slide between which they are confined, from the field of view; and now, a small twig, and two or three minute leaves, with a few flakes of mucus, and a turbid condition of the water from the presence of earthy particles, are the only objects the eye can discern. All the diversified forms of life that were sporting in the apparently wide waste of water have vanished from our sight, and are as though they were not; yet what a world of wonders, what a marvellous display of Infinite Wisdom, are there concealed! Within that narrow space, the microscope has shewn us the mysterious principle of vitality embodied in structures of which we had previously no conception; and under conditions, which, if estimated according to our experience of the visible creation, would appear incompatible with animal existence.

Were we to describe the facts that have come under our notice to persons unacquainted with the optical powers of the microscope, and tell them, that the seemingly particles of earth in the water, are creatures of various forms and structures, endowed with life, and the capacity for its enjoyment; that those flakes of mucus, are aggregated thousands of animals in the shape of flowers, which increase, like plants, by buds and by self-division; that some of these creatures are carnivorous, feeding on living atoms more infinitesimal than themselves; that others are herbivorous, and nourished by particles of decomposed vegetables, too minute to be visible till accumulated in the internal organs of the animalcules; that we selected some of these animals, and caused them to swallow carmine, and thus imparted a red colour to their digestive organs, and rendered their structure more obvious; that some are free, and roam through the water at pleasure,—others always sedentary,—others locomotive in youth, and fixed to one spot in after-life; that many have eyes, the number and colour of which can be distinguished; that the difference in the relative magnitude of these creatures is as great as that between a mouse and an elephant; that if the water in which these beings are now immersed be allowed to evaporate, and the sediment become as dry as dust, and this be moistened

three or four years hence, many of the individuals at this moment sporting through the water will be resuscitated and appear in full activity, although, had they remained in their native element, the term of their existence would have extended but through a few days,—thus realising one of the beautiful fictions of Arabian story; would not this statement be deemed unworthy of belief? would it not be regarded as improbable and as extravagant, as the wildest chimeras of the imagination? And yet such a narrative would be but the simple truth; an unexaggerated, unadorned, matter-of-fact summary, of the phenomena that have come under our observation!

XVI.

GENERAL REMARKS ON THE INFUSORIA.—CONCLUSION.

The Infusoria, like animals of higher organisation, suffer and perish from sudden transitions of temperature. They die in ice; but, when the water first congeals, each animalcule is surrounded by a moist space, caused by the caloric liberated from its own body*. A high temperature also destroys them: Vorticellæ often die under the microscope, if exhibited in a hot room. Atmospheric air is as necessary for the Infusoria, as for the warm-blooded animals. They are killed by substances which affect the chemical composition of the water; but the strongest poisons, if only in mechanical suspension in the fluid, exert no influence upon them. Fresh-water species instantly die if sea-water be suddenly added, though the latter may swarm with marine species; but they survive if the mixture be gradual, and many kinds inhabit brackish waters.

* Ehrenberg.

Infusoria always appear in vegetable infusions, simply because their ova or germs, being everywhere present, find in such fluids a proper medium for their development: hence the same kinds of infusions do not always contain the same species of animalcules.

The atmosphere, which is always charged with infinitesimal particles of matter, both organic and inorganic, wafts in every breeze immense quantities of the sporules of plants*, and of the ova of animalcules. The rapid increase of the Infusoria yields a never-failing supply of their germs, and countless myriads are, therefore, everywhere ready to burst into life, and go through their assigned phases of development, when placed under the conditions specially required by the type of organisation to which they belong†.

* The sporules of some *Fungi* are so minute, and occur in such immense numbers, that in a single individual (of *Reticularia*) more than ten millions have been counted; and they are so light and subtle, that they are dispersed by the slightest agitation of the air, and even by evaporation. The germs of these minute and simple forms of vegetation must, therefore, always be present in the atmosphere.

† The *Acari* observed by Mr. Cross in the fluids of his galvanic apparatus, cannot justly be regarded as offering a valid objection to this explanation of the phenomenon. The appearance of these Acari, notwithstanding the precautions employed to exclude or destroy their ova, in the experiments of Mr. Cross and Mr. Weekes, does not present the same difficulty as the occurrence of *Entozoa* in the chambers of the human eye, &c. *See Appendix.*

Though the influence of light is favourable to infusorial life, it does not appear to be absolutely necessary, for many kinds of animalcules abound in the waters of deep mines, which are always in impenetrable darkness.

The ordinary duration of life in the Infusoria varies from a few hours to several days, or even weeks: Rotifera have been traced to the twenty-third day of their existence. The death of these animals is generally sudden; but, in some of the larger species, convulsive struggles attend their dissolution. Shortly after death, the soft parts rapidly decompose, and all traces of their beautiful structures disappear: the species which are furnished with earthy cases or shells, alone leave durable vestiges of their existence*.

The exceedingly small proportion of solid matter that enters into the composition of these animals is remarkable: from aggregated myriads and myriads, a few atoms of dust alone remain! If it be supposed that the bodies of the Infusoria are too minute to afford any conclusive evidence on this point, it may be remarked that the same phenomenon appears in certain

* The oceans that deposited those ancient sedimentary strata, in which no traces of organic remains have been observed, (and are therefore called by some geologists *azoic*), may, consequently, have been as densely peopled with gelatinous organisms as the existing seas. *See Appendix.*

other animal structures; for example, in the *Medusæ**, many of which are of considerable bulk, some a yard in diameter, and several pounds in weight, yet, after death, their entire structure rapidly melts away, and the only solid residuum is a thin film of membrane, weighing but a few grains. The *Physalia*, so familiar to voyagers by the common name of "Portuguese Man-of-war†," and which skims along the surface of the sea at pleasure, using its little crest as a sail, and often appearing in mimic fleets of thousands on the calm expanse of the ocean, consists only of an oblong bladder wrinkled into a crest above, and sending off numerous attenuated filaments from below. When taken out of the water, it shrinks into a shapeless mass of jelly, and all its substance evaporates, leaving a portion of earthy matter, relatively as inconsiderable as the residual dust of the innumerable hosts of the Infusoria. Thus, in the Medusæ, as in the animalcules, all the functions of

* The *Medusæ* are those elegant hyaline cup-shaped gelatinous animals, commonly known by the name of Jelly-fish, or Sea-blubber; and which, in the warm days of summer, may often be seen swarming in thousands in the sea near our coasts, as at Southampton, Portsmouth, &c. If one as large as a saucer is caught in the hand, and taken out of the water, it instantly collapses into a small mass of jelly. "A Medusa weighing two pounds when first taken out of the sea, dried up to only thirty grains of solid matter."—*Professor Owen.*

† *Physalia pelagica*; see Vignette of title-page.

vitality are performed by structures, whose constituent substance is scarcely more dense than the surrounding element in which they dwell; yet, in these frail tenements, these mere definite aggregations of globules, life is for awhile enshrined, and confers the power of resisting the chemical and mechanical effects of external agents, of traversing the ocean, of pursuing live prey, of taking cognisance of danger, and of escaping from its approach. But the moment that life departs, the materials of which these organisms are composed, released from the dominion of the laws of vitality, are resolved into fluid molecules, and rapidly pass into their original elementary condition.

FINAL EFFECTS.—With regard to the consideration of the general purposes in the economy of Nature which these invisible beings are destined to effect, I would leave the intelligent reader to draw his own inferences from what has been advanced; being convinced, that no well-regulated mind can rise from the contemplation of the marvels revealed by the microscope, without being so deeply impressed with a sense of awe, of humility, and of dependence, as to be secured from the arrogance and presumption of attempting to interpret the final purposes of the ETERNAL, even in the minutest of HIS works.

We may, indeed, take cognisance of some of the obvious results of the operations of these living atoms; such, for example, as their influence in maintaining the purity of the atmosphere and of the water, by the conversion into their own structures of the particles liberated by the decomposition of the larger animals and vegetables; and, in their turn, becoming the food of other races, and thus affording the means of support to creatures of a higher organisation than themselves. We see, too, that many species, after death, give rise to the formation of earthy deposits at the bottoms of lakes, rivers, and seas, which, in after-ages, may become fertile tracts of country, and the sites of large communities of mankind. But in this, as in all attempts to interpret the mysterious designs of Providence, we are but as "beings darkly wise;" for it is probable that many of the most serious maladies which afflict humanity, are produced by peculiar states of invisible animalcular life. From some periodical and exaggerated condition of development, particular species, too minute for the most powerful microscope to descry, may suddenly swarm in the air or in the waters, and penetrating the internal vessels and organs, exert an injurious influence of a specific character on the lining membranes, and fluids, of the human frame. And from this inscrutable agency may, possibly, ori-

ginate the Cholera, Influenza, and other epidemic diseases*.

I NOW take farewell of the "COURTEOUS READER," who has indulgently accompanied me through this imperfect attempt to illustrate some of the important subjects, involved in the microscopical investigation of the Invisible World of Being. Amply will my labours be rewarded, should they induce any of the young and intelligent to enter upon a department of science so replete with interest and instruction, and which is in the highest degree calculated to exert the most beneficial influence on the character, by leading the mind from frivolous and unworthy pursuits, and exciting in it those aspirations after truth and wisdom, which elevate the soul above the petty passions and prejudices of common life. "For who can contemplate the marvellousness of GOD'S works, and not think his best and

* For a full and able consideration of this most important and interesting question, the reader is referred to "Medical Notes and Reflections," (by Henry Holland, M.D., &c.; London: 1839), chap. xxxiv, "On the Hypothesis of Insect Life as a Cause of Disease." In the opinions of this eminent medical philosopher on this subject I entirely concur.

most adoring thoughts on the subject*?" And this salutary tendency it possesses in common with every other branch of natural knowledge; for such is the consummate perfection of all the works of the CREATOR, that whatever path of inquiry we may select for our especial investigation, if followed in a right spirit, will conduct us to the "Fountain of living waters,"—to the source of all Truth and Wisdom.

> From myriads take thy choice,
> In all that lives a guide to GOD is given;
> Ever thou hear'st some Angel-guardian's voice,
> When Nature speaks of Heaven!†

Thus, in the impressive language of Dr. Chalmers, while the *Telescope* enables us to see a system in every star, the *Microscope* unfolds to us a world in every atom. The one instructs us that this mighty globe, with the whole burthen of its people and its countries, is but a grain of sand in the vast field of immensity—the other, that every atom may harbour the tribes and families of a busy population. The one shews us the insignificance of the world we inhabit—the other redeems it from all its insignificance, for it tells us, that in the leaves of every forest, in the flowers of every

* Leigh Hunt's "Visit to the Zoological Gardens," 1836.
† "The Guardian Angel," by Sir E. B. Lytton, Bart.

garden, in the waters of every rivulet, there are worlds teeming with life, and numberless as are the stars of the firmament. The one suggests to us, that above and beyond all that is visible to man, there may be regions of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the Universe—the other, that within and beneath all that minuteness which the aided eye of man is able to explore, there may be a world of invisible beings; and that could we draw aside the mysterious veil which shrouds it from our senses, we might behold a theatre of as many wonders as Astronomy can unfold; a Universe within the compass of a point, so small as to elude all the powers of the miscroscope, but where the ALMIGHTY RULER of all things finds room for the exercise of HIS attributes, where he can raise another mechanism of worlds, and fill and animate them all with evidences of HIS glory!

APPENDIX.

Analogy not Identity, see note to page 24.

SINCE this note was written, the Author of the "Vestiges of the Natural History of Creation" has published his "Explanations," as a sequel to the former work, in which he states, that he never intended to aver that the embryotic condition of the mammal is to be regarded as *identical* with the permanent state of the Monad; and declares that he simply meant to express the *resemblance*, or analogy, which the mammal bears, in the various stages of its development, to certain inferior types of animal organisation. "Perhaps," he observes, "no part of the arguments for the development theory has been more misapprehended, or misrepresented, than this. It is continually said, that the embryo, at any of its particular stages, is not in reality the animal represented by

"that stage.———The truth is, no one ever pretended that there was such an identity. It is only said, that there is a resemblance in general character between the particular embryotic stage of being, and the mature condition and form of the appropriate inferior animal*." He then adverts to a special charge brought against him, that he assumes "not only that the organic germs of all creatures are alike, but that they are identical," which he states was not his meaning; but simply, "that the embryos of all animals are not distinguishably different from each other†;" a proposition which but few physiologists will be disposed to impugn. In justification of myself, and of those who, like me, have misapprehended, (not misrepresented), this author's opinions, I quote the following passage, which may be regarded as a concise expression of his theory.

"The idea, then, which I form of the progress of organic life upon our earth—and the hypothesis is applicable to all similar theatres of vital being—is, *that the simplest, and most primitive type, under a law to which that of like-production is subordinate, gave birth to the type next above it,* that this again produced the next higher, and so on to the very highest, the stages of advance being in all cases very small—namely from one

* Explanations, p. 108. † Ibid, p. 109.

species only to another; so that the phenomenon has always been of a simple and modest character*." The "Explanation" first quoted appears to me irreconcilable with this doctrine.

It would be foreign to the object of the present work, to notice other opinions advanced in "The Vestiges," which bear upon some of the phenomena described in the text; but I would strongly recommend those who are interested in the subject, to peruse with serious attention, and unprejudiced mind, the "*Explanations*" of this able anonymous author. I venture to offer one word of caution, namely, that the arguments in proof of the development theory, derived from fossil organic remains, should not, in the present state of our knowledge of the ancient inhabitants of the globe, be regarded as conclusive. The evidence hitherto obtained is insufficient to warrant the assertion, that "the remains and traces of plants and animals found in the succession of strata, show that the earth gradually became the theatre of organic being,—*simple forms appearing first, and more complicated afterwards. A time when there was no life is first seen; we then see life begin, and go on*," &c.† The hasty generalisationson this topic, in which many eminent geologists and palæontologists

* Vestiges of the Natural History of Creation, 4th ed., p. 231.

† Explanations, p. 30.

have indulged, are much to be regretted, for they have been assumed from insufficient data, and can only be regarded as shifting hypotheses, to be modified, confirmed, or rejected, with the progress of discovery. The ingenious manner in which the shrewd author of "The Vestiges" has brought these speculations to bear in support of his own hypotheses, will, I trust, prove a salutary caution.

Organic Cells, p. 25.—In examining animal structures with the highest powers of the microscope, a primogenial nucleated cell suddenly terminates our analysis, and forms the extreme limit of our power of investigation. Cells, therefore, appear to constitute the minute and marvellous laboratory, in which the essential changes of organic life are performed; all the various processes of vitality being effected by the agency of cells, not distinguishable from each other by any appreciable physical characters. Thus, one system of cells secretes the bile, another the adipose substance, another the nervous matter, and so forth; but how these special products are formed by cells, apparently of similar organisation, from the same nutrient fluids, we know not. Whether the special endowment belonging to the system of cells of a particular organ, depends on the intimate structure of the walls or tissue

of such cells, and this structure be so attenuated and infinitesimal as to elude observation; or whether it results from the transmission of some peculiar modification of that mysterious vital force we term nervous influence, are questions, to which, in the present state of our knowledge, no satisfactory reply can be given.

Localities of Fresh-water Infusoria, p. 28.—The following remarks on the situations in which the different kinds of fresh-water animalcules may generally be found, offer some useful suggestions to the inexperienced observer*.

In stagnant and putrid water, the ordinary forms of Infusoria only are met with; but in clear pools and streams the most elegant species abound, and are often found clustering around, or attached to the stems and under-sides of the leaves of aquatic plants. Twigs, leaves, &c., that are beneath the surface of the water, particularly such as appear to be coated with slime, will be found to harbour myriads of Vorticellæ, Rotifers, &c. The yellow, green, blue, reddish, and brown mucus floating on the surface, generally swarms with interesting and beautiful species.

* Translated from Mandl's "Traité pratique du Microscope."

In collecting Infusoria, several clear phials, with wide mouths, and cork stoppers, are necessary; and a good pocket magnifier, with three lenses of different powers, will be required, to examine objects on the spot, that useless or uninteresting specimens may be rejected. The phials should be filled with fresh water nearly to the top; and small portions of the aquatic plants, to which animalcules are attached, should be collected; but the phials must not be crowded with leaves or stems. The corks must be removed as soon as possible, for if the air is long excluded, many of the animalcules will perish. In winter, Infusoria may often be found around the Confervæ under the frozen water. In searching for animalcules in a muddy pond, it is advisable that some of the water should be poured through a piece of linen, or silk, to get rid of the extraneous matter; for the Infusoria will pass through the filter, and thus be more easily detected.

To procure the Infusoria from vegetable infusions, it is only necessary to put fruit, hay, grass, or other vegetable matter, into water, and expose it in open vessels for a few days: a pellicle or film of mucus will soon appear on the surface, and be found to consist almost entirely of animalcules.

To select specimens for examination, a small quantity of water from one of the phials should be poured into a

watch-glass placed on a card, or board, half of which is black, and the other white; by this means the dark-coloured animalcules will easily be recognised on the white surface, and the transparent ones, on the black ground. The minutest kinds often congregate around the margin of the water in the glass.

Particular species may be selected by means of a glass tube, and placed on a glass slide under the microscope: powers magnifying from 300 to 400 will be required for their proper inspection. The larger and isolated forms, as the Stephanoceros, Limnias, Melicerta, &c., should be taken up with a feather or camel-hair pencil: by a little practice, an individual may easily be isolated and placed in a live-box, or between two slips of glass. If the animalcules are not attached to any vegetable substance, a small fragment of a leaf should be interposed between the two pieces of glass, that they may not be compressed and destroyed.

Fossil Infusoria, p. 81.—That those infinitesimal forms of existence, whose presence in our lakes, rivers, and seas, can only be made manifest by the aid of the microscope, should be detected in a fossil state, and their aggregated skeletons or shields constitute entire chains of hills, and the subsoil of extensive tracts of

country, is one of the most interesting discoveries of modern Geology*.

The peat-bogs and swamps, both of modern and ancient date, often contain masses of a white, marly, siliceous paste, wholly made up of the shells of Infusoria. Such is the white earthy substance found in the peat-bogs of Ireland, Yorkshire, &c. The polishing-slate of Bilin, in Prussia, forms a series of strata fourteen feet thick, and is entirely composed of the siliceous shields of Infusoria, of such extreme minuteness, that a cubic inch of the stone contains forty-one thousand millions of distinct organisms!

In Virginia there are extensive beds of siliceous marls, that are largely composed of the durable shields of various kinds of marine animalcules. When a few grains of this earth are properly prepared for the microscope, numerous species of the most exquisite forms are visible: in fact, the merest stain left by the evaporation of a drop of water in which some of the marl has been mixed, teems with beautiful infusorial structures. This aggregation of the fossil remains of beings, so minute, as to be invisible to the naked eye, forms strata several yards in thick-

* This subject is treated at length in my "Medals of Creation," chap. vii.

ness. The towns of Richmond and Petersburgh, in Virginia, are built upon this infusorial sandstone.

All the species of animalcules found in the Richmond earth are marine; and many of them belong to genera, (if not to species), that inhabit the present seas, although the position of these American strata proves that they are referable to a very remote geological epoch. Some of the prevalent Richmond forms, (the *Coscinodisci*, or sieve-like disks), live in the British Channel; and my son, (Mr. REGINALD MANTELL), detected in the mud of the quicksands along the shore at Brighton, the shields of numerous recent Coscinodisci, associated with fossil Infusoria washed out of the neighbouring chalk-cliffs.

Another interesting discovery in connexion with this subject may here be noticed. The common scallops, as well as other mollusks, feed on Infusoria, and their stomachs often contain thousands of shells, which, being siliceous, have resisted the process of digestion. A glass slide mounted with a few particles of the undigested contents of the stomach of a scallop, presents an assemblage of infusorial shells, apparently identical with those forming the Richmond earth*. So close, indeed, is the analogy, not only of the individual shields, but even

* Mr. HAMLIN LEE first noticed this interesting fact.

of their collocation, that it would be difficult for an experienced observer to distinguish slides, mounted with the respective organisms, from each other; although one group is from deposits of unfathomable antiquity, and the other from the British Channel*.

The *guano* from Ichaboe, when long digested in dilute hydrochloric acid, leaves a siliceous residuum, which consists of shields of Coscinodisci and other marine Infusoria, of exquisite beauty.

Entozoa, or internal Parasitical Animals†, note to p. 86.—Though the hypothesis enunciated in the text, which is founded on the doctrine of the celebrated Hervey—"*omne vivum ab ovo*"—satisfactorily accounts for the presence of Infusoria and other minute organisms under ordinary circumstances, and is sanctioned by direct observation to an almost unlimited extent, yet there are peculiar states and conditions under which animalcular life becomes developed, that are inexplicable in this view of the subject; and are, indeed, incomprehensible in the present state of our knowledge. Such, for instance, as the occurrence of the various

* See my "Notes of a Microscopical Examination of Chalk and Flint," in the Annals of Natural History, August, 1845.

† The *Entozoa* live in the internal parts of other animals; and some of the Entozoa are themselves infested with parasites.

kinds of *Entozoa*, many of which are restricted to particular organs of particular species of animals, and are themselves the theatre of existence to other parasitical beings!

Here, as Dr. Holland emphatically remarks*, we approach to speculations, which, though founded on the most minute forms of existence, have yet a vastness in their obscurity, and in the results to which their solution would lead. Hence the questions arise, whether animal or vegetable life, (for the inquiry equally regards both), is in any case produced, except from the eggs or germs of prior individuals of the same species? whether there may not be matter so constituted, as to be capable, from the influence of some unknown law, of assuming an organic character, and giving rise to particular species of living beings, whenever the conditions suitable to the development and continuance of such organisms are present? The theory of the origination of living beings from inorganic elements, or, to use the expression of the author of the "Vestiges," "*of organic creation by law*," offers a solution to these difficult problems; but no certain evidence has yet been obtained to substantiate, or even sanction this hypothesis.

* Medical Notes and Reflections, p. 579.

This, in fact, is the serious, and only legitimate objection to a doctrine, which would explain many obscure physiological phenomena, and bring the laws of vitality into harmony with those which preside over the inorganic kingdom of nature.

Azoic sedimentary Strata, note to p. 87.—From the absence of all traces of animal and vegetable structures, or more properly from the *non-discovery of organic remains,* in the most ancient sedimentary strata, (those, for example, below the *Lower Silurian*), some eminent geologists infer that the deposition of these rocks was antecedent to the creation of organic beings. This inference appears to me most unphilosophical; for negative evidence, as it is termed, in the present state of geological science, is in fact no evidence at all, as we are still but imperfectly acquainted with the entire system of organic nature in any one of the grand epochs of Geology.

If we endeavour to trace the order of succession of animal and vegetable organisation upon our planet, as demonstrated by fossil remains, we are at once impressed with the insufficiency of the data hitherto obtained, to present us with a true picture of the full development of organic life, as it existed in the earlier ages of the

earth's physical history*. How little do we know of the Faunas and Floras even of those countries whose spoils now constitute the dry land of the south-east of England! For example, no traces of Infusoria have been detected in the Wealden strata, though diligent search has been made by competent observers; yet no naturalist will doubt that the mollusks and crustaceans, (*Cyprides*), found in those fluviatile deposits, fed upon fresh-water animalcules, like their recent congenors; and it is probable, that, sooner or later, fossil Infusoria will be discovered in the Wealden formation. The following remark of Mr. Lyell is in accordance with the opinions above expressed:—"It is too common a fallacy to fix the era of the first creation of each tribe of plants or animals, and even of animate beings in general, at the precise point where our present retrospective knowledge happens to stop †."

A similar fallacy pervades the ingenious speculations as to the relative depths in the ocean in which certain strata were originally deposited, as indicated by the presence or absence of particular species of shells; the geographical and vertical range of their presumed living analogues being taken as the data upon which these

* See "The Medals of Creation, Vol. II, p. 872.

† Lyell's Travels in North America.

generalisations are based. Thus, in the absence of all positive evidence, a considerable portion of the cretaceous formation is stated to have been formed by deposits "*not far from the zero of animal life**;" and this startling assertion is deemed by the author of the "Vestiges,"† "a satisfactory explanation of the non-appearance of forms intermediate to the reptiles and mammals in the chalk"!

Change of Climate, note to p. 26.—To avoid misapprehension, I would observe, that it is not intended to deny or undervalue the great benefits to be derived from a change of climate, and the selection of a suitable air and residence, for persons labouring under pulmonary affections, and which are so forcibly pointed out in the classic work of that eminent physician *Sir James Clark;* but simply to denounce the too common practice, of neglecting the most effectual remedial measures in those states of disease, which climatorial influence alone can neither remove nor ameliorate.

* Ansted's Geology.

† Explanations, a Sequel to the Vestiges, p. 93.

MISCELLANEOUS NOTES.

BACILLARIA.—Should this Volume meet the eye of the naturalist, the omission of any notice of the numerous family of *Bacillaria*, (the Stick-like Animalcules of Ehrenberg), some species of which are generally present in water containing Infusoria, will require explanation. It has arisen from the opinion that notwithstanding the observations of M. Ehrenberg, the animal nature of these organisms is very doubtful. I am more inclined, with the botanists, to refer them to the vegetable kingdom, and consider them as Algæ, belonging to the order *Desmidiaceæ*, than as being in any way related to the Infusoria.

MICROSCOPES.—The microscope employed in the investigations described in the text, was an achromatic made by Mr. Ross, the eminent optician, (Featherstone

Buildings, Holborn, London). Mr. Ross's Educational Microscope is a cheap and good instrument.

Excellent microscopes are made by Mr. Smith, (Ironmonger Row, St. Luke's), Messrs. Powell & Lealand, (Clarendon Street, Somers Town), and other well-known London opticians.

Mr. Andrew Pritchard, (162, Fleet Street), who by his various works has greatly promoted the taste for microscopic investigations in this country, has furnished many of my friends with an excellent microscope, of sufficient power for every useful purpose, at the price of from 7*l.* 7*s.* to 12*l.* 12*s.*

Mr. Pritchard has published an abstract of Ehrenberg's Classification of Infusoria, with numerous figures, under the name of "A History of Infusoria, living and fossil," 1 vol. 8vo. Whittaker & Co., London, 1845; it may be had with the plates either uncoloured or coloured, (price 30*s.*); the latter is well worth the additional price. This work is the best in the English language, for those who desire to follow up this interesting department of natural history.

There is a cheap French work on the microscope, which will be found an excellent manual; it is entitled "*Traité pratique du Microscope, et de son Emploi dans l'Etude des Corps organisés, par le Docteur* L. MANDL; *suivi de Recherches sur l'Organisation des Animaux*

Infusoires, par D. C. G. EHRENBERG; *accompagné de* 14 *Planches.*" *A Paris,* 1839: *Bailliére, Regent Street, London;* price 8*s.* This volume explains the mechanism of the best modern microscopes, describes the various modes of examining organic and inorganic subjects, and presents an abstract of Ehrenberg's arrangement and nomenclature of Infusoria. The plates contain 188 uncoloured figures of the principal genera; which, though of very coarse execution, will enable the observer to identify the usual forms.

Mr. Dancer (13, Cross Street, King Street, Manchester) supplies a good microscope and the necessary apparatus, in a neat mahogany box, with the highest power magnifying 250 linear, at 7*l.* 15*s.*; and with an additional power magnifying 400 linear, 10*l.* 18*s.* I am informed by Mr. Williamson, surgeon, Manchester, (a gentleman well known for his important microscopical investigations), that these instruments are very excellent, and are the only ones he has employed.

OBJECTS FOR THE MICROSCOPE.—My country readers may find it useful to be informed that objects for examination, both recent and fossil, may be obtained of Mr. Topping, 1, York Place, Pentonville, London. The usual price is 1*s.* 6*d.* a slide; but very rare objects, and such as are difficult to prepare, are from 2*s.* to 3*s.*

each. Glass tubes, live-boxes, and all the usual requirements for microscopical investigation, may also be obtained of Mr. Topping.

Mr. Darker, Paradise Row, Lambeth, is an excellent artist, and well known for the neatness and finish of his microscopical preparations and instruments, objects for the polarization of light, &c.

Instructions for the preparation of fossil teeth, bones, wood, &c., for microscopical examination, are given in my "Medals of Creation; or, First Lessons in the Study of Organic Remains."

Drawings of microscopic subjects.—By means of a Camera Lucida attached to the microscope, a person accustomed to draw will be able, after a little practice, to delineate any object. To those who require an artist either to make the original drawing, or to transfer it to stone, zinc, &c., I would recommend Mr. Lens Aldous, (4, New Street, Surrey Zoological Gardens, London), as an experienced and able artist; the exquisite plates in Professor Owen's "*Odontography*" justify this commendation; the lithotints of the present volume are specimens of his skill in this branch of art.

DESCRIPTION

OF THE

PLATES.

DESCRIPTION OF PLATE I.

THE HYDRÆ, OR FRESH-WATER POLYPES.

(PAGE 12.)

[*The Figures are slightly enlarged, for the sake of distinctness.*]

FIG. 1. Three Green Polypes, (*Hydra viridis*), attached to the stem of an aquatic plant, p. 13.

a, The base or pedicle of the Hydra.

b, The mouth and arms.

FIG. 2. The Common Fresh-water Polype, (*Hydra vulgaris*), partly contracted, and the stomach distended with food.

FIG. 3. The Long-armed Polype, (*Hydra fusca*), with the arms extended in search of food, p. 15.

c, A small red worm seized by one of the tentacula, or arms.

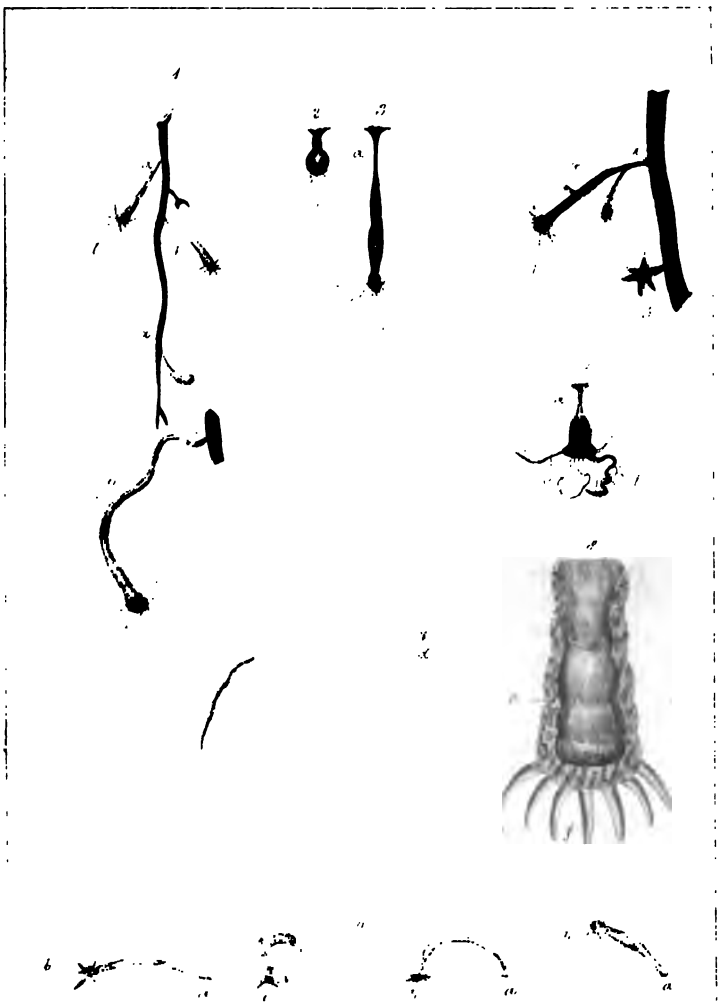
d, An aquatic insect, caught by another of the arms.

FIG. 4. The *Hydra vulgaris* attached to a twig: two young ones are seen sprouting from the sides of the body, p. 14.

FIG. 5. The *Hydra vulgaris* in a contracted state.

FIG. 6. The *Hydra fusca* moving to and fro in the water in quest of prey, p. 15.

FIG. 7. The *Hydra fusca*, with a worm, which it has partly swallowed; the extremities hanging out of the mouth, and secured by the tentacula of the Polype, p. 15.



The Hydræ or Fresh Water Polypes

FIG. 8. A longitudinal section of a Polype magnified, p. 15.

e, The cellular structure of the substance of the body.

f, The arms, or tentacula, shewn to be hollow prolongations from the body.

g, The lining, or villous coat, of the stomach or digestive sac.

FIG. 9. The *Hydra viridis*, in the various attitudes it assumes when moving from place to place, p. 14.

a, The base, or pedicle.

b, The mouth and arms.

DESCRIPTION OF PLATE II.

THE MONADS AND STENTORS.

(PAGE 36.)

[*All the Figures highly magnified.*]

FIG. 1. The *Vibriones*, or Trembling Animalcules. Several groups of these Monads united in filiform chains: the undulated form is assumed when these creatures are moving through the water; p. 41.

FIG. 2. The Tablet Monads, (*Gonium pectorale*); a group of sixteen individuals; p. 38.

FIG. 2*a*. Two detached animalcules of the Breastplate Gonium, (*Gonium pectorale*), more highly magnified.

FIG. 3. A group of four individuals of the Cloaked Monad, (*Chlamidomonas*), produced by the spontaneous division of two individuals; p. 37.

FIG. 4. A group of the Terminal Monad, (*Monas termo*).

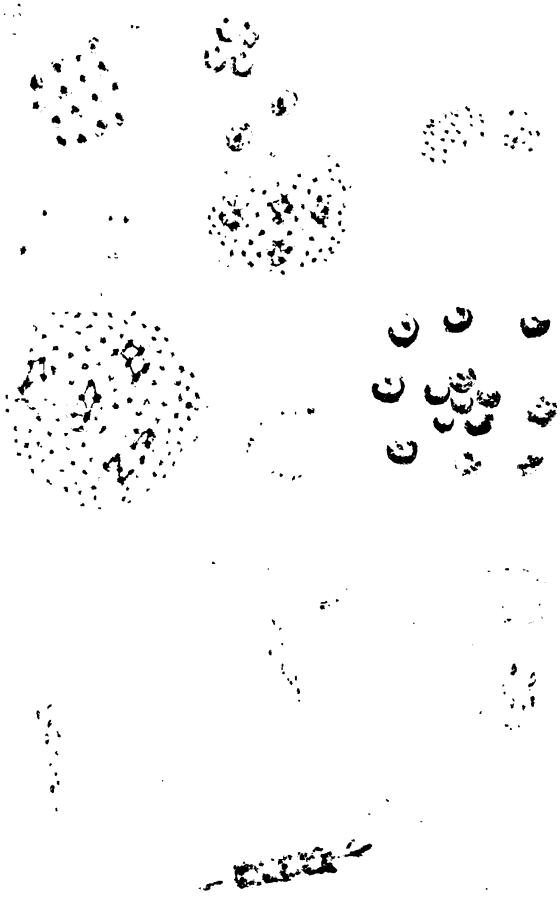
FIG. 5. The Viviparous Monad, (*Monas vivipara*); p. 37.

FIG. 6. A group of the Red Monad, (*Monas vinosa*, so named from its colour); the *originals* extremely minute.

FIG. 7. Two detached individuals of the Dust Chlamidomonas, (*C. pulviculus*); p. 37.

a, A single animalcule.

b, A Monad, in which the fissuration into two individuals has commenced.



IG. 8. The *Monas vivipara;* an individual dividing into two; p. 37.

FIG. 9. The Revolving Monads, (*Volvox globator*); representing the young escaping from the parent globe; p. 39.

FIG. 10. The Globe Volvox, (*V. globator*); five young globular clusters are contained within the outer or parent globe; p. 40.

FIG. 11. A single Monad of the Globe Volvox, very highly magnified; shewing the red eye-speck, the horns, the six connecting lateral filaments, and the globular sacs; p. 39.

FIG. 12. Part of the globe of a *Volvox*, magnified 500 linear; shewing in the centre several groups of the Monads produced by self-division; p. 39.

FIG. 13. The Blue Stentor, (*Stentor cæruleus*); p. 44.

a. The lateral crest, only partially seen in this position.

FIG. 14. A group of the Multi-shaped Stentor, (*Stentor polymorphus*); p. 43.

FIG. 15 Shews a *Stentor polymorphus* in a form it often assumes when floating through the water.

FIG. 16. A twig, covered with thousands of the *Stentor polymorphus*, which appear to the naked eye like an incrustation of green jelly; from the lake in the garden of Dulwich College. This twig was from a branch three feet long, that had fallen into the water, and was literally covered with innumerable aggregations of these Infusoria; p. 44.

DESCRIPTION OF PLATE III.

THE VORTICELLÆ, OR BELL-SHAPED ANIMALCULES.

(PAGE 42.)

[*All the Figures highly magnified.*]

FIG. 1. The Arborescent Vorticella, (*Carchesium polypinum*), seen with a low power. This group is formed by the spontaneous fissuration being incomplete. *See* p. 48.

a, *a*, Two individuals thrown off from the parent stem. An enlarged view of one of these liberated animalcules is shewn in fig. 4.

FIG. 2. One of the Vorticellæ of fig. 1, highly magnified, shewing the process of fissuration, by which one animalcule becomes two individuals, each supported by a stem, and continuing attached to the parent trunk; p. 48.

FIG. 3. A group of Vorticellæ, (*Vorticella nebulifera*), representing the animalcules in various attitudes. Some are single, others have divided into two; some are extended, others have their pedicles or stems more or less spirally contracted; in several instances the pedicles are destitute of bodies, the animalcules having broken the connexion, and swam off; p. 44.

FIG. 4. An animalcule of the group fig. 3, separated from the pedicle, and having a row of cilia at the base; p. 47.

[illegible] Bell shaped Animalcules
[illegible]

FIG. 5. The appearance to the naked eye of thousands of Vorticellæ surrounding the roots of two or three leaves of the Lemna; p. 42.

FIG. 6. A group of three Vorticellæ, (*Vorticella campanulata*), in various states of contraction. A foreshortened view of the body is shewn in the left-hand figure.

These animalcules are represented as fed with carmine; with the exception of the Vorticellæ in the upper part of the group fig. 3, which are shewn of their natural appearance, their globular sacs being filled with green matter.

DESCRIPTION OF PLATE IV.

THE LIMNIAS, OR WATER-NYMPH.

(PAGE 58.)

[*The Figures highly magnified.*]

A group of eight individuals of the Hornwort Limnias, (*Limnias ceratophylli*), is here represented.

a, The animalcule entirely withdrawn into its tubular case.

b, The rotatory organs and cilia fully expanded in the parent animalcule, within the sheath of which several eggs, (*e*, *e*,), may be distinguished.

The animalcules are represented in different states of protrusion and expansion from their tubular cases, or sheaths.

The Limnias or Water Nymph

DESCRIPTION OF PLATE V.

THE MELICERTA, OR HONEY FLOSCULARIA.

(Page 59.)

[*The Figures highly magnified.*]

Fig. 1. The jaws and teeth of the Melicerta, very highly magnified, (copied from Ehrenberg).

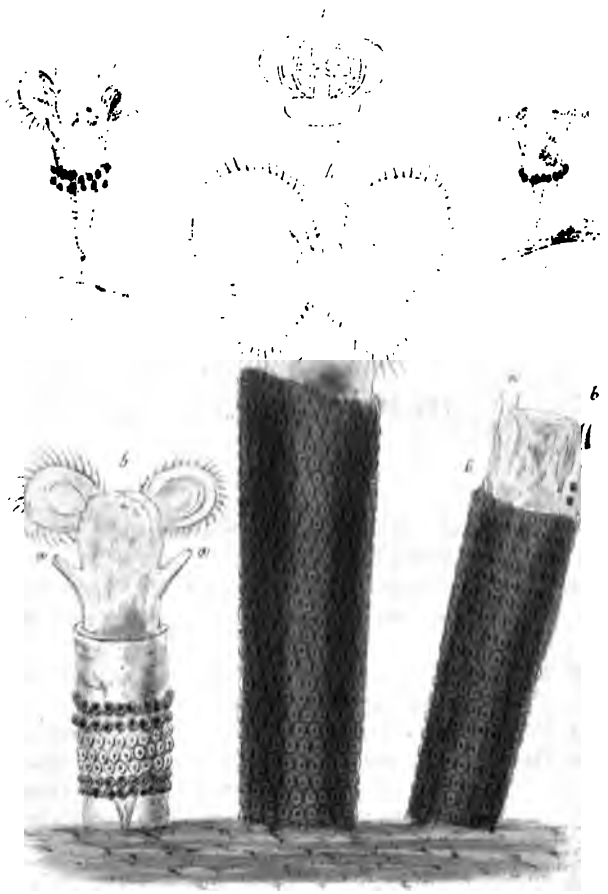
Fig. 2. A very young individual of the Beaded Melicerta, (*M. ringens*), with two rows of corpuscles on the sheath, coloured by carmine.

Fig. 3. The same animalcule in an earlier stage, with only one ring of corpuscles on the sheath, or case.

Fig. 4. The adult Melicerta, with the rotatory organs fully expanded.

Fig. 5. The individual figured above, (figs. 2 and 3), in a more advanced stage. The granular case consists of several rows of corpuscles, of which the two upper and lower rows are coloured by carmine; p. 60.

Fig. 6. An adult Melicerta; the body but partially protruded.



Lens Aldous lithogr

The Beaded Melicerta
Natural Size & of a line.

DESCRIPTION OF PLATE VI.

THE FLOSCULARIA, OR FLOWER-SHAPED ANIMALCULE.

(PAGE 61.)

[*The Figures highly magnified.*]

Two individuals of the Elegant Floscularia, (*Floscularia ornata*), attached to a stem of Chara; the natural size is from $\frac{1}{5}$ to $\frac{1}{3}$ of a line.

FIG. 1. The animalcule protruded from its transparent case.

a, The jaws and teeth.

b, The stomach, containing Monads, Naviculæ, and other small polygastrian animalcules.

FIG. 2. A Floscularia, with the body wholly withdrawn into its case, the termination of the long cilia alone appearing externally.

c, An egg in the ovisac, containing a young one, in which the red eyes may be discerned.

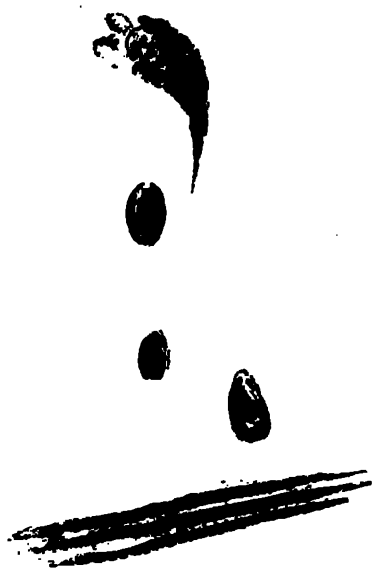
DESCRIPTION OF PLATE VII.

THE FLOSCULARIA ORNATA, OR ELEGANT FLOSCULARIA.

(Page 61.)

In this example, the upper part of the body of the animalcule, with the rotatory organs, is protruded, and bending over the margin of the tube, or sheath.

Three ova, in various stages of development, are seen within the case.



DESCRIPTION OF PLATE VIII.

THE FLOSCULARIA PROBOSCIDEA, OR HORNED FLOSCULARIA.

(PAGE 61.)

This species of Flower-shaped Animalcule has a ciliated proboscis, or horn, (*a*), surrounded by the rotatory organs, which are furnished with short cilia. In this example the animal is fully extended; the jaws are distinctly seen; the stomach filled with food, and one egg within the sheath, are also visible.

DESCRIPTION OF PLATE IX.

THE STEPHANOCEROS, OR CROWNED WHEEL-ANIMALCULE.

(PAGE 63.)

Two individuals of the Stephanoceros, (*Stephanoceros Ehrenbergi*), are here represented attached to the stem of an aquatic plant.

FIG. 1. The animalcule fully protruded from its transparent sheath. The rotatory organs, composed of five long tentacula furnished with rows of short verticillate cilia, are extended in the form of an elongated dome, the extremities meeting in the centre.

a, Small oval bodies, supposed to be nervous centres, (*ganglia*)' to supply the tentacula, p. 66.

b, The trembling organs, p. 66.

c, The jaws and teeth, p. 67.

d, The stomach.

e, The transparent case.

FIG. 2. The animal shrunk down towards the bottom of the case. The upper part of the arms, pressed together in an obtuse elongated cone, alone appears above the margin of the sheath, p. 65.

DESCRIPTION OF PLATE X.

DEVELOPMENT OF THE OVA OF THE STEPHANOCEROS.

(PAGE 67.)

Two individuals of the *S. Ehrenbergi*, shewing the development of the ova.

FIG. 1. In this example an egg, (*e*), is seen in an advanced stage of development. The same ovum, two hours later, is shewn in pl. XI, fig. 4, *e;* p. 68.

FIG. 2. Two eggs, (*e, e*), almost arrived at maturity, were observed in the Stephanoceros here figured. The lowermost one, (*e**), was watched till it burst, and the young animal escaped into the parent sheath. It is shewn at *h*, making its way towards the bottom, from which it ultimately escaped; p. 68.

DESCRIPTION OF PLATE XI.

ILLUSTRATION OF THE DEVELOPMENT OF THE YOUNG STEPHANOCEROS.

(PAGE 67.)

FIG. 1. The young animalcule, represented in pl. x, (fig. 2, *h*), as it appeared thirty hours after its exclusion from the parent sheath; p. 69.

a, Apparently the rudiments of the arms.

c, The cilia.

FIG. 2. The same individual eighty hours after exclusion; the body appears much shortened from being somewhat contracted; p. 69.

a, The arms, five in number; but only four are seen in this view.

b, The stomach.

FIG. 3. A young Stephanoceros eighty-four hours after exclusion from the egg, but still retained within the sheath of the parent, which perished; p. 69*.

a, The arms, or tentacula.

b, The jaws.

s, Remains of the sheath of the parent.

FIG. 4. A sketch of part of the body of a Stephanoceros, to shew the development of the egg; p. 68.

* The above three figures were drawn with the camera lucida; the magnifying power employed was the ½-inch object glass of Ross's Achromatic.

Lens Aldous lithogr.

The Development of the Young of the Stephanoceros

s, The sheath.

e, The egg.

f, The pellucid zone, around the embryo.

g, The nucleus, having a constant semi-rotatory motion.

h, *h*, Part of the body of the parent animalcule.

This egg was watched by Mr. Lee till it burst, and the young was excluded into the sheath of the parent; from whence, in four hours, it escaped, from the upper part of the case; p. 68.

DESCRIPTION OF PLATE XII.

ROTIFERS, OR WHEEL-ANIMALCULES.

(Page 71.)

Fig. 1. The Pitcher-shaped Brachionus, (*B. urceolaris*); p. 79.

a, The jaws.

b, The carapace, or shell.

c, The pair of rotators.

d, The pedicle, or tail.

e, *e*, Ova, or eggs, attached to the body of the animalcule.

Fig. 1*a*. The jaws and teeth of fig. 1, highly magnified.

Fig. 2. Baker's Brachionus, (*B. Bakeri*); p. 89; the letters have the same references as above.

Fig. 2*a*. The jaws and teeth of Baker's Brachionus.

Fig. 3. The Common Wheel-animalcule, (*Rotifer vulgaris*); reduced from Ehrenberg's figure; p. 73.

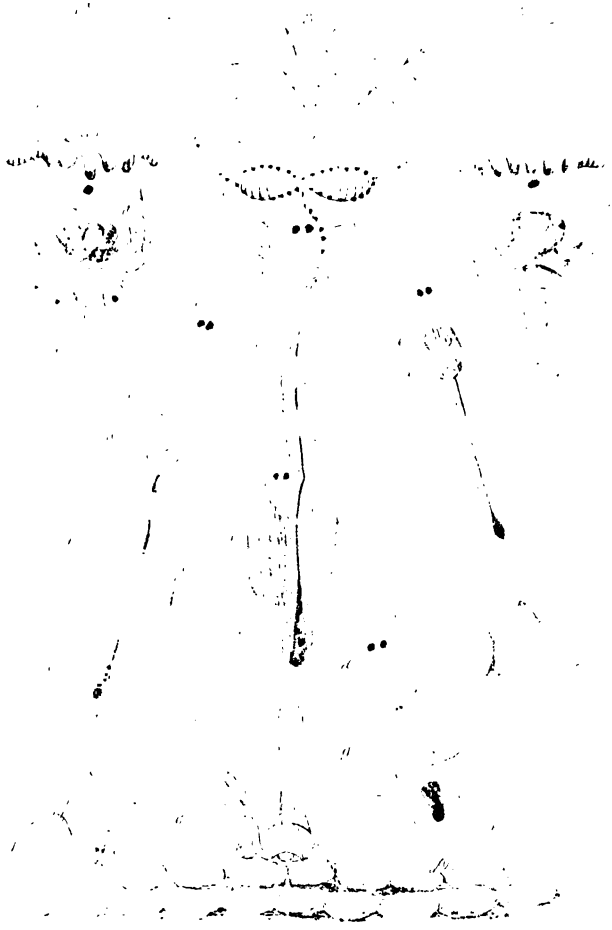
a, The trunk or proboscis, on which the two red eyes are placed.

b, *b*, The rotators, or wheels. The course of the eddies induced by the cilia is denoted by the arrows.

c, The respiratory tube.

d, The masticatory apparatus, or jaws and teeth.

e, *e*, The alimentary canal coloured by carmine. The direction of the currents occasioned by the vibration of the cilia of the mouth is shewn by the coloured arrows.



T. Rotors or Wheel Animalcules

f, Four bundles of long internal muscles.

g, Eggs in the ovisac; the red eyes of one of the young are very manifest.

h, The tail, or pedicle.

FIG. 4. A Rotifer with the proboscis, (*a*), extended, and the wheels, (*b*, *b*), withdrawn, appearing like two hemispherical radiated disks.

d, The jaws and teeth.

e, The stomach.

h, The pedicle.

FIG. 5. A young Rotifer just escaped from the egg; p. 75.

FIG. 6. A Rotifer with the body bent over arch-wise, in the act of moving along the surface of the stem of a plant. Locomotion is performed as in the Hydræ (see pl. 1, fig. 9); p. 76.

FIG. 7. A Wheel-animalcule with the body much shrunk down, and the wheels drawn in; a few cilia only appearing at the mouth, (*a*); p. 76.

d, The masticatory apparatus.

g, The red eyes of an embryo in the ovisac.

h, The pedicle.

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